

**REPORT NUMBER 216a-MGA-20-006**

**SAFETY COMPLIANCE TESTING FOR FMVSS 216a  
“Roof Crush Resistance”**

\*\*\*\*\*

**2020 BMW 3-SERIES  
NHTSA No. C20204100**

VIN No. WBA5R1COXLFH53825

**Prepared By:  
MGA RESEARCH CORPORATION  
446 Executive Drive  
Troy, Michigan 48083**



**Test Date: September 21-22, 2020  
Report Date: October 7, 2020**

**FINAL REPORT**

**PREPARED FOR:**

**U.S. DEPARTMENT OF TRANSPORTATION  
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION  
ENFORCEMENT  
OFFICE OF VEHICLE SAFETY COMPLIANCE  
1200 New Jersey Avenue, SE  
WASHINGTON, D.C. 20590**

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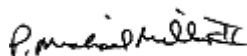


Prepared By:

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Fern Gorman, Project Leader



\_\_\_\_\_  
Helen A. Kaleto, Laboratory Manager



Approved By:

\_\_\_\_\_  
P. Michael Miller II, Vice President

Approval Date:      October 6, 2020

FINAL REPORT ACCEPTANCE BY OVSC:

Accepted By:      James A. Jones

Acceptance Date:      10-7-2020

## TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 216a-MGA-20-006	2. Government Accession No.	3. Recipient's Catalog No.	
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		6. Performing Organization Code MGA	
7. Author(s) Helen A Kaleto, Laboratory Manager Fern Gorman, Project Engineer Jacob Briskey, Test Engineer, Mark Pytell, Test Personnel		8. Performing Organization Report No. 216a-MGA-20-006	
9. Performing Organization Name and Address MGA Research Corporation 446 Executive Drive Troy, Michigan 48083		10. Work Unit No.	
		11. Contract or Grant No. DTNH22-16-D-00028	
12. Sponsoring Agency Name and Address U.S DEPARTMENT OF TRANSPORTATION National Highway Traffic Safety Administration Enforcement Office of Vehicle Safety Compliance 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period Covered Final Test Report 09/21/2020 – 09/22/2020	
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15. Supplementary Notes			
16. Abstract Compliance tests were conducted on roof from a 2020 BMW 3-Series, NHTSA No. C20204100, in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No. TP-216a-00 for the determination of FMVSS 216a compliance. The testing was conducted at MGA Research Corporation in Troy, Michigan on September 21-22, 2020. Test failures identified were as follows: None			
17. Key Words Compliance Testing Safety Engineering FMVSS 216a	18. Distribution Statement Copies of this report are available from: National Highway Traffic Safety Administration Technical Information Services Division, NPO-411 1200 New Jersey Avenue SE (Room E12-100)  E-Mail: <a href="mailto:tis@nhtsa.dot.gov">tis@nhtsa.dot.gov</a> FAX: 202-493-2833		
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## **1.0 Purpose of Compliance Test and Test Procedure**

Purpose: The tests performed are part of the safety compliance program for the National Highway Traffic Safety Administration (NHTSA) by MGA Research Corporation under Contract No. DTNH22-16-D-00028. The purpose of the testing is to determine whether the subject vehicle, 2020 BMW 3-Series meets certain performance requirements of FMVSS 216a, "Roof Crush Resistance". The compliance test was conducted in accordance with OVSC Laboratory Test Procedure No. TP-216a-00 dated May 6, 2009.

Test Procedures: The "MGA Research Corporation Testing Procedure for FMVSS 216a", submitted to and approved by the National Highway Traffic Safety Administration, contains the specific procedures used to conduct testing.

This procedure shall not be interpreted to conflict with any portion of NHTSA TP-216a-00, FMVSS 216a nor any amendment thereof within the applicable contract.

## **2.0 Compliance Test Data Summary**

The roof of a 2020 BMW 3-Series was required to sustain a maximum load of 46,643.1 N (3 x UVW) on both the right and left sides of the vehicle with platen displacement of 127 mm or less. The left side sustained a maximum load of 46,346 N at 30 mm of platen travel. The right side sustained a load of 47,081 N at 29 mm of platen travel. No head contact was observed.

### 3.0 Test Data and Results

#### Data Sheet 1

##### GENERAL TEST AND VEHICLE PARAMETER DATA

NHTSA No.: C20204100      Test Date: 09/21/2020      Side Tested: Driver/Passenger  
Laboratory: MGA Research Corporation      Test Technician(s): Jacob Briskey

##### TEST VEHICLE INFORMATION:

Year/Make/Model/Body Style: 2020 BMW 3-Series 4-Door  
Body Color: Black      VIN: WBA5R1COXLFH53825  
Build Date: July 2019      Odometer Reading: 449 miles  
Engine Data: 4 Cylinders CID      Liter cc  
Engine Placement: X Longitudinal or Lateral  
Transmission: Speed Manual X Automatic Overdrive  
Drive: X Rear Wheel Drive Front Wheel Drive Four Wheel Drive  
Safety Restraints: Seat belts and airbags

##### DATA FROM TIRE SIDEWALL:

Size of the tires on test vehicle: 225/45 R18      Manufacturer: Pirelli  
Tire Pressure for Max. Load Carrying Capacity: 340 kPa Front 340 kPa Rear  
Treadwear: 500      Traction: A      Temperature: A

##### DATA RECORDED FROM VEHICLE PLACARD OR TIRE LABEL:

Recommended Tire Size: 225/45 R18 XL  
Recommended Cold Tire Pressure: 220 kPa Front 260 kPa Rear

##### VEHICLE CAPACITY DATA:

Number of Occupants 2 Front 3 Rear 5 Total  
Type of Front Seats X Buckets Bench Split Bench  
Type of Front Seatback Fixed X Adjustable with Lever or X Knob

**List of Components Removed:** Underbody trim, 1st row seats, and carpet

##### UNLOADED VEHICLE WEIGHT:

Right Front 406.5 kg      Right Rear 393.0 kg  
Left Front 407.0 kg      Left Rear 380.0 kg  
Total Front 813.5 kg      Total Rear 773.0 kg  
Total Weight: 1,586.5 kg      % of Total weight in Front: 51.3      % of Total weight in Rear: 48.7

##### TEST VEHICLE ATTITUDE:

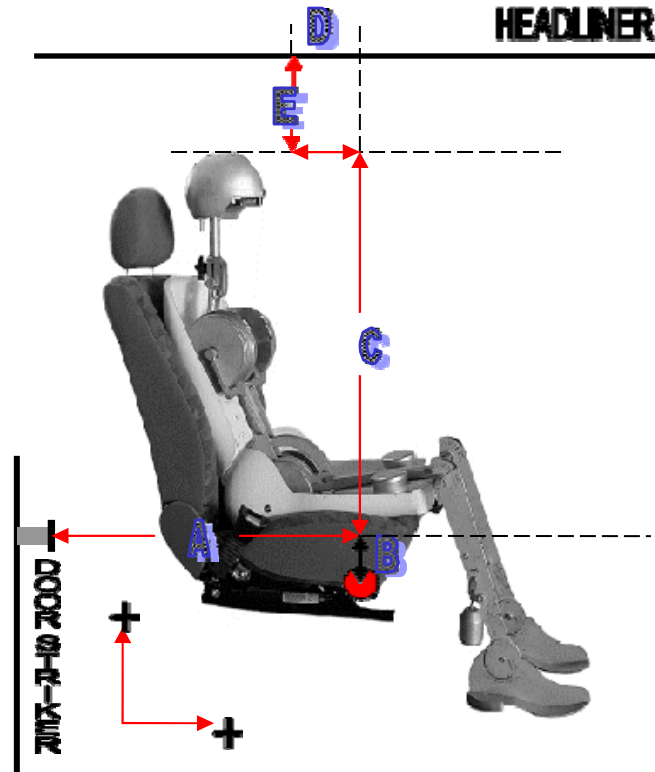
Pitch Attitude: (Nose Down (ND), Nose Up (NU))  
Initial: Right Door Sill Angle 1.1° (ND)      Left Door Sill Angle 1.2° (ND)  
Final: Right Door Sill Angle 0.1° (ND)      Left Door Sill Angle 0.1° (ND)  
Roll Attitude:  
Initial: Left-side 708      Right-side 705  
Final: Left-side 763      Right-side 760

Jacob Briskey  
Technician Signature

09/21/2020  
Date

## Data Sheet 2

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Driver  
 Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell



H-Point Data (mm)

		J826 Only	After HRMD Installed
HRMD	Torso Angle	25.2°	25.3°
	X (=A) – fore/aft of striker	144.5	148.5
	Z (=B) – Above/below striker below	-264.4	-264.9

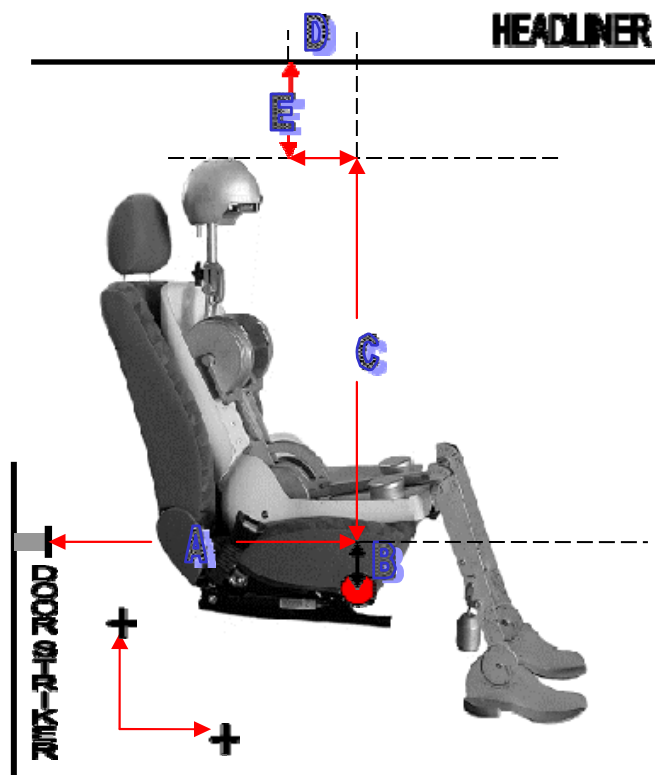
Positioning Data (mm)

C	487.5
D	174.7
E	102.2

- A – Horizontally from the door striker to the H-point
- B – Vertically from the H-point to the door striker
- C – Vertically from the door striker to the top of the head
- D – Horizontally from the center of the head to the H point
- E – Vertically from the top center of the head to the headliner

### Data Sheet 3

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Passenger  
 Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell



H-Point Data (mm)

		J826 Only	After HRMD Installed
HRMD	Torso Angle	24.8°	25.1°
	X (=A) – fore/aft of striker	140.3	141.3
	Z (=B) – Above/below striker below	-266.7	-267.5

Positioning Data (mm)

C	486.8
D	168.6
E	109.9

- A – Horizontally from the door striker to the H-point
- B – Vertically from the H-point to the door striker
- C – Vertically from the door striker to the top of the head
- D – Horizontally from the center of the head to the H point
- E – Vertically from the top center of the head to the headliner



## Data Sheet 4

### Test Information – First Tested Side

NHTSA No.: C20204100 Test Date: 09/21/2020 Side Tested: Driver  
Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell

### A. Driver Side Pre-Test Data

Levelness of the Tie-Down Surface/Platform (0 +/- 0.5°): 0.0° Platen  
Platen Angles: Pitch Angle: 5° Roll Angle: 25°  
Platen Alignment at Vehicle Longitudinal Centerline: 634 mm  
Max. Applied Force for Vehicles w/GVWR ≤ 2722 kg = UVW 1,586.5 x 9.8 x **3.0** = 46,643 N  
Max. Applied Force for Vehicles w/GVWR > 2722 kg = UVW N/A x 9.8 x **1.5** = N/A N  
1. Any convertible top, movable or removable roof structure in their closed positions: Yes  
2. Close all windows, close and lock all doors: No        Yes X  
3. The test device will initially contact the roof at 185 mm aft of windshield.  
4. HRMD Top Center of Head Position (Driver): X: -26.3 Y: -394.4 Z: 487.6  
5. HPF 201 Head form Top Center of Head Position (Driver): X: -26.2 Y: -394.6 Z: 487.5  
HPF device properly aligned: Yes

### B. Post Test Data

Maximum load achieved = 46,346 N at 30 mm of displacement.  
Did the maximum load achieved reach the maximum applied force (0,-250N)?        No-Fail X Yes-Pass  
Did head contact occur? No X Yes        at        mm of displacement  
Was a 222 N head resultant force attained? No-Pass X Yes-Fail        at        mm of displacement.  
Did the platen travel exceed 127 mm? No-Pass X Yes-Fail         
Did the windshield break? No X Yes        at        mm of displacement.  
Did the sun roof panel(s) break? No X Yes        N/A       

### Description of damage and deformation that occurred during the test:

Permanent deformation on upper roof door structure on the driver side.

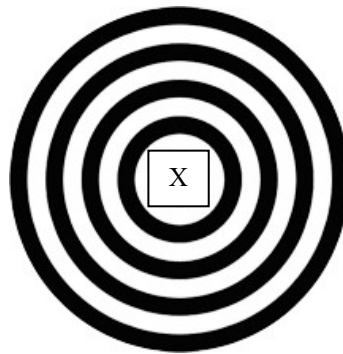
### Data Sheet 4 Continued

#### Test Information – First Tested Side

Did the second HPF shift from its original position? No X Yes \_\_\_\_ Distance \_\_\_\_

Indicate in the picture below where the second HPF center is located versus the original position (center).

**NOTE:** The distance between each concentric circle is 2 mm.



## Data Sheet 5

### Test Information – Second Tested Side

NHTSA No.: C20204100 Test Date: 09/22/2020 Side Tested: Passenger  
Laboratory: MGA Research Corporation Test Technician(s): Jacob Briskey, Mark Pytell

### A. Passenger Side Pre-Test Data

Levelness of the Tie-Down Surface/Platform (0 +/- 0.5°): 0.0° Platen  
Platen Angles: Pitch Angle: 5° Roll Angle: 25°  
Platen Alignment at Vehicle Longitudinal Centerline: 638 mm  
Max. Applied Force for Vehicles w/GVWR ≤ 2722 kg = UVW 1,586.5 x 9.8 x **3.0** = 46,643 N  
Max. Applied Force for Vehicles w/GVWR > 2722 kg = UVW N/A x 9.8 x **1.5** = N/A N  
1. Any convertible top, movable or removable roof structure in their closed positions: Yes  
2. Close all windows, close and lock all doors: No        Yes X  
3. The test device will initially contact the roof at 185 mm aft of windshield.  
4. HRMD Top Center of Head Position (Passenger): X: -27.2 Y: 411.7 Z: 486.7  
5. HPF 201 Head form Top Center of Head Position (Passenger): X: -27.3 Y: 411.7 Z: 486.8  
HPF device properly aligned: Yes

### B. Post Test Data

Maximum load achieved = 47,081 N at 29 mm of displacement.  
Did the maximum load achieved reach the maximum applied force (0,-250N)?        No-Fail X Yes-Pass  
Did head contact occur? No X Yes        at        mm of displacement  
Was a 222 N head resultant force attained? No-Pass X Yes-Fail        at        mm of displacement.  
Did the platen travel exceed 127 mm? No-Pass X Yes-Fail         
Did the windshield break? No X Yes        at        mm of displacement.  
Did the sun roof panel(s) break? No X Yes        N/A       

### Description of damage and deformation that occurred during the test:

Permanent deformation on upper roof door structure on the passenger side.

#### 4.0 TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

ITEM	MFR	MODEL	S/N	CALIB. PERIOD	DATE OF LAST CALIB.	ACCURACY
LVDT 1	MTS	G-Series	LVDT 1	12 Months	10/11/2019	0.164%
LVDT 2	MTS	G-Series	LVDT 2	12 Months	10/11/2019	0.164%
LVDT 3	MTS	G-Series	LVDT 3	12 Months	10/11/2019	0.164%
LVDT 4	MTS	G-Series	LVDT 4	12 Months	10/11/2019	0.164%
Load Cell 1	Interface	1220AF-50K	305372	12 Months	12/13/2019	0.93%
Load Cell 2	Interface	1220AF-50K	568559	12 Months	12/14/2019	0.93%
Load Cell 3	Interface	1220AF-50K	281953	12 Months	12/13/2019	0.93%
Load Cell 4	Interface	1220ACK-50K	557637	12 Months	12/13/2019	0.93%
Load Cell 5	Interface	1220ACK-50K	1019124	12 Months	12/13/2019	0.93%
Load Cell 6	Interface	1220AF-50K	305366	12 Months	12/14/2019	0.93%
Load Cell 7	Interface	1220AF-50K	305386	12 Months	12/14/2019	0.93%
HPF Load Cell	Humanetics	9555TF	DH9302	12 Months	10/08/2019	0.20%
Inclinometer	MIT	Pro 360	MGA00173	12 Months	03/16/2020	0.062° + 0.6R
Tape Measure	Stanley	33-215	TPM003-86	12 Months	04/29/2020	1 mm
Force Gauge	Imada	DS2-110	MGA00975	12 Months	11/20/2019	.2%
CMM	FARO	N/A	C12-D2-05-03364	12 Months	07/02/2020	±0.345 mm

MICHIGAN OPERATIONS  
DATE: 03/18/2019  
SUPERCEDES: MGTPLVDT.4

DOC. NO.: MGATP\_LVDT\_CAL  
REVISION NO.: 5  
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Linear Voltage Displacement Transducer (LVDT)  
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT-1	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N:	216-LVDT-1	S/N:	TPM009-37
Range:	24"	Capacity:	12'
Calibration Date:	10/11/2019	Calibration Date:	03/19/19
Calibration DueDate:	10/11/2020	Calibrated By:	Nevastar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.082	Intercept
5.00	5.04	0.164	-0.02
7.50	7.52	0.082	
10.00	10.04	0.164	
12.50	12.54	0.167	
15.00	15.04	0.167	
17.50	17.53	0.125	
20.00	20.04	0.167	
22.50	22.52	0.083	Maximum Error
24.00	24.00	0.000	0.167

\*: percent Error calculated by  $100 * (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# MT0095) used to monitor temperature and Relative Humidity.

Temperature	% Relative Humidity
68.4°F	39%

Performed By: yshawant

Approved By:

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is ±0.7%.  
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor k=2.

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Linear Voltage Displacement Transducer (LVDT)  
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT - 2	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N	216-LVDT2	S/N:	TPM 005-37
Range	24"	Capacity:	12'
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date	10/11/2020	Calibrated By:	Navastar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.082	Intercept
5.00	5.00	0.000	-0.01
7.50	7.52	0.082	
10.00	10.00	0.000	
12.50	12.52	0.082	
15.00	15.00	0.000	
17.50	17.52	0.082	
20.00	20.04	0.164	
22.50	22.52	0.082	Maximum Error
24.00	24.00	0.000	0.164

\* percent Error calculated by  $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# NI0095) used to monitor temperature and Relative Humidity.

Temperature	% Relative Humidity
68.4 F	39%

Performed By: yauwant

Approved By:

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is  $\pm 0.7\%$ .  
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor  $k=2$ .

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DATE: 03/18/2019  
SUPERCEDES: MGTPLVDT.4

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Linear Voltage Displacement Transducer (LVDT)  
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT-3	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N:	216-LVDT3	S/N:	TPM005-37
Range:	24"	Capacity:	12
Calibration Date:	10/11/2019	Calibration Date:	03/19/19
Calibration Due Date:	10/11/2020	Calibrated By:	Novastar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.52	0.082	Intercept
5.00	5.00	0.000	-0.01
7.50	7.52	0.082	
10.00	10.04	0.164	
12.50	12.56	0.246	
15.00	15.04	0.164	
17.50	17.56	0.246	
20.00	20.04	0.164	
22.50	22.56	0.246	Maximum Error
24.00	24.00	0.000	0.246

\* percent Error calculated by  $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# ME0095) used to monitor temperature and Relative Humidity.

Temperature	% Relative Humidity
66.4°F	39%

Performed By: ybawant

Approved By:

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is  $\pm 0.7\%$ .  
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor  $k=2$ .

MICHIGAN OPERATIONS  
DATE: 03/18/2019  
SUPERCEDES: MGTPLVDT 4

DOC. NO: MGATP\_LVDT\_CAL  
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Linear Voltage Displacement Transducer (LVDT)  
Verification for the MAST/Hydraulic Cylinders

Sensor Information		Reference Sensor Information	
Name:	LVDT-43	Name:	Tape Measure
Model:	MTS	Model:	Stanley
S/N	216-LVDT 4	S/N:	TPM 005-37
Range	24"	Capacity:	12'
Calibration Date	10/11/2019	Calibration Date:	03/19/19
Calibration DueDate	10/11/2020	Calibrated By:	Navastar

Measured Values		Reproduced from Calculated Slope	
Distance (in)	Measured Distance (in)	% Error *	Scale factor Best Fit Line (mm/V)
0.00	0.00	0.000	1.00
2.50	2.49	0.082	Intercept
5.00	5.00	0.000	0.00
7.50	7.52	0.082	
10.00	10.00	0.000	
12.50	12.52	0.082	
15.00	15.00	0.000	
17.50	17.52	0.082	
20.00	20.00	0.000	
22.50	22.52	0.082	Maximum Error
24.00	24.00	0.000	0.082

\* percent Error calculated by  $100 \times (\text{Measured} - \text{Calculated}) / \text{Measured Range}$

Calibrated thermometer (ID# MT 005) used to monitor temperature and Relative Humidity.

Temperature	% Relative Humidity
68.4°F	39%

Performed By: ysawant

Approved By:

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is ±0.7%.  
All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor k=2.

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17025 Accredited Certificate of Calibration

Certificate #: 4842690008 e T



Acct #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220AF-50K
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	305372A
Contact:	Troy, MI, 48083	Asset Number:	
PO #:	MI20037	Barcode:	

As Received	As Returned	Action Taken	Cal Date:
In Tolerance X	In Tolerance X	Full Calibration X	12/13/2019
Out of Tolerance	Out of Tolerance	Special Calibration	Due Date: 12/13/2020
Malfunctioning	Malfunctioning	Oper. Verification	Temperature: 73.00 deg. F
Operational	Operational	Adjusted	Humidity: 35.00 %
Damaged	N/A	Repaired	Baro. Press.:
N/A		Charted	Procedure: DCN 50345
		Returned As Is	Reference: ASTM E74 (2018) / local
			Dept:

Incoming Remarks:

#### Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft nfg spec. The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

#### Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of 1-2 unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540-3:2006, MIL-STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.  
\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: *Randy Johnson*

QA Approved:



1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690008

### Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 305372A

Account Number: 088470  
Technician: M. Schneider  
Cal. Date: 12/19/2019  
ID: 305372A

#### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0016	
10000	8.268	8.2636	0.011 %
20000	16.523	16.5255	-0.006 %
30000	24.785	24.7873	-0.006 %
40000	33.052	33.0491	0.007 %
50000	41.310	41.3108	-0.002 %
20000	16.494	16.5255	
0	0.000	0.0016	

#### Linear Coefficients

A= 1.6428571E-03  
B= 8.2620071E-04  
C= -3.5714286E-13

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.169 mV  
Input Resistance: 351.20 Ohms  
Output Resistance: 351.19 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.133 mV		35261.4 lbf	70.5 %



## Report of Calibration

Report Number: 4842690008

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 305372A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/13/2019  
ID: 305372A

### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0007	
10000	-8.292	-8.2907	0.003 %
20000	-16.582	-16.5823	-0.001 %
30000	-24.875	-24.8755	-0.001 %
40000	-33.170	-33.1703	-0.001 %
50000	-41.467	-41.4667	0.001 %
20000	-16.572	-16.5823	
0	0.000	-0.0007	

#### Linear Coefficients

A= -6.7857143E-04  
B= -8.2891821E-04  
C= -8.0357143E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.169 mV  
Input Resistance: 351.20 Ohms  
Output Resistance: 351.19 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	- Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.129 mV		35123.1 lbf	70.2 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690009 e T



<b>Acct #:</b> 088470	<b>Manufacturer:</b> Interface, Inc.
<b>Customer:</b> MGA Research Corporation	<b>Model:</b> 1220AF-50K
<b>Shipper #:</b> No Shipper	<b>Description:</b> Load Cell
<b>Address:</b> 2807 Elliott	<b>Serial Number:</b> 568559A
<b>Contact:</b> Troy, MI, 48083	<b>Asset Number:</b>
<b>PO #:</b> MI20037	<b>Barcode:</b>

<b>As Received</b>	<b>As Returned</b>	<b>Action Taken</b>	<b>Cal Date:</b> 12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	<b>Due Date:</b> 12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	<b>Temperature:</b> 73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	<b>Humidity:</b> 35.00 %
Operational	Operational	Adjusted	<b>Baro. Press.:</b>
Damaged	N/A	Repaired	<b>Procedure:</b> DCN 50345
N/A		Charted	<b>Reference:</b> ASTM E74 (2018) / local
		Returned As Is	<b>Dept:</b>

Incoming Remarks:

**Technical Remarks:**

Calibrated with tension base torqued to 55 lb-ft mfg spec  
The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

Calibration Standards Utilized					
Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	1C48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of  $k=2$  unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540-3:2006, MIL-STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.  
\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signature:

QA Approved:

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690009

### Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 568559A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/14/2019  
ID: 568559A

#### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0003	
10000	8.393	8.3932	-0.001 %
20000	16.790	16.7878	0.005 %
30000	25.182	25.1841	-0.005 %
40000	33.582	33.5820	0.000 %
50000	41.982	41.9816	0.001 %
20000	16.786	16.7878	
0	0.000	0.0003	

#### Linear Coefficients

A= 3.2142857E-04  
B= 8.3920607E-04  
C= 8.3928571E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.162 mV  
Input Resistance: 351.28 Ohms  
Output Resistance: 351.15 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.132 mV		34695.8 lbf	69.4 %



## Report of Calibration

Report Number: 4842690009

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 568559A

Account Number: 088470  
Technician: M. Schneider  
Cal. Date: 12/14/2019  
ID: 568559A

### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0014	
10000	-8.440	-8.4376	0.006 %
20000	-16.873	-16.8729	0.000 %
30000	-25.307	-25.3074	-0.001 %
40000	-33.739	-33.7410	-0.005 %
50000	-42.175	-42.1737	0.003 %
20000	-16.855	-16.8729	
0	0.000	-0.0014	

#### Linear Coefficients

A= -1.4285714E-03  
B= -8.4366000E-04  
C= 4.2857143E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load\*2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.162 mV  
Input Resistance: 351.28 Ohms  
Output Resistance: 351.15 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.089 mV		34486.1 lbf	69.0 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690011 e T



<b>Acct #:</b>	088470	<b>Manufacturer:</b>	Interface, Inc.
<b>Customer:</b>	MGA Research Corporation	<b>Model:</b>	1220AF-50K
<b>Shipper #:</b>	No Shipper	<b>Description:</b>	Load Cell
<b>Address:</b>	2807 Elliott	<b>Serial Number:</b>	281953A
	Troy, MI, 48083	<b>Asset Number:</b>	
<b>Contact:</b>	Scott Arsen	<b>Barcode:</b>	
<b>PO #:</b>	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft wfg spec  
The estimated measurement uncertainty is 13 lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	1C48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of 1-2 unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540-3:2006, MIL STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.  
\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: Randy Whitson

QA Approved:

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Report Number: 4842690011

## Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 281953A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/13/2019  
ID: 281953A

### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0006	
10000	8.202	8.2029	-0.002 %
20000	16.424	16.4199	0.010 %
30000	24.651	24.6514	-0.001 %
40000	32.893	32.8976	-0.011 %
50000	41.161	41.1585	0.006 %
20000	16.441	16.4199	
0	0.000	0.0006	

#### Linear Coefficients

A= 6.4285714E-04  
B= 8.1949643E-04  
C= 7.3214286E-11

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.019 mV  
Input Resistance: 350.97 Ohms  
Output Resistance: 350.98 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.097 mV		35345.4 lbf	70.7 %





## Report of Calibration

Report Number: 4842690011

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 281953A

Account Number: 088470  
Technician: M. Schneider  
Cal. Date: 12/13/2019  
ID: 281953A

### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0008	
10000	-8.263	-8.2635	-0.001 %
20000	-16.533	-16.5351	-0.005 %
30000	-24.815	-24.8139	0.003 %
40000	-33.102	-33.1000	0.005 %
50000	-41.392	-41.3933	-0.003 %
20000	-16.524	-16.5351	
0	0.000	0.0008	

#### Linear Coefficients

A= 8.2142857E-04  
B= -8.2607036E-04  
C= -3.6250000E-11

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.019 mV  
Input Resistance: 350.97 Ohms  
Output Resistance: 350.98 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.148 mV		35209.7 lbf	70.4 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690001 e T



<b>Acct #:</b>	088470	<b>Manufacturer:</b>	Interface, Inc.
<b>Customer:</b>	MGA Research Corporation	<b>Model:</b>	1220ACK-50K
<b>Shipper #:</b>	No Shipper	<b>Description:</b>	Load Cell
<b>Address:</b>	2807 Elliott Troy, MI, 48083	<b>Serial Number:</b>	557637A
<b>Contact:</b>	Scott Arsen	<b>Asset Number:</b>	
<b>PO #:</b>	MI20037	<b>Barcode:</b>	

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft mfg spec  
The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

12/17/2019

The above identified unit was calibrated in our laboratory at the address shown below.

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ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: Randy Johnson

QA Approved:

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Report Number: 4842690001

## Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220ACK-50K  
Description: Load Cell  
Serial Number: 557637A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/13/2019  
ID: 557637A

### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0029	
10000	8.263	8.2589	0.010 %
20000	16.525	16.5230	0.005 %
30000	24.793	24.7950	-0.005 %
40000	33.071	33.0751	-0.010 %
50000	41.366	41.3631	0.007 %
20000	16.475	16.5230	
0	0.000	0.0029	

#### Linear Coefficients

A= 2.8571429E-03  
B= 8.2520571E-04  
C= 4.0000000E-11

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.28 mV  
Input Resistance: 351.47 Ohms  
Output Resistance: 351.33 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.134 mV		35214.9 lbf	70.4 %



Report Number: 4842690001

### Report of Calibration

**Manufacturer:** Interface, Inc.  
**Model:** 1220ACK-50K  
**Description:** Load Cell  
**Serial Number:** 557637A

**Account Number:** 088470  
**Technician:** M. Schneider  
**Cal. Date:** 12/13/2019  
**ID:** 557637A

### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0023	
10000	-8.324	-8.3197	0.010 %
20000	-16.636	-16.6358	0.001 %
30000	-24.947	-24.9504	-0.008 %
40000	-33.264	-33.2635	0.001 %
50000	-41.576	-41.5753	0.002 %
20000	-16.618	-16.6358	
0	0.000	-0.0023	

#### Linear Coefficients

A= -2.2857143E-03  
B= -8.3181714E-04  
C= 7.1428571E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC      Input Resistance: 351.47 Ohms  
Zero Balance: 0.28 mV      Output Resistance: 351.33 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.077 mV		34968.5 lbf	69.9 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690005 e T



<b>Acct #:</b>	088470	<b>Manufacturer:</b>	Interface, Inc.
<b>Customer:</b>	MGA Research Corporation	<b>Model:</b>	1220ACK-50K-B
<b>Shipper #:</b>	No Shipper	<b>Description:</b>	Load Cell
<b>Address:</b>	2807 Elliott	<b>Serial Number:</b>	1019124A
	Troy, MI, 48083	<b>Asset Number:</b>	
<b>Contact:</b>	Scott Arsen	<b>Barcode:</b>	
<b>PO #:</b>	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/13/2019
In Tolerance X	In Tolerance X	Full Calibration X	<b>Due Date:</b>	12/13/2020
Out of Tolerance	Out of Tolerance	Special Calibration	<b>Temperature:</b>	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	<b>Humidity:</b>	35.00 %
Operational	Operational	Adjusted	<b>Baro. Press.:</b>	
Damaged	N/A	Repaired	<b>Procedure:</b>	DCN 50345
N/A		Charted	<b>Reference:</b>	ASTM E74 (2018) / local
		Returned As Is	<b>Dept:</b>	

**Incoming Remarks:**

Top plate bent

**Technical Remarks:**

The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

**Calibration Standards Utilized**

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/I345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

12/17/2019  
SA

The above identified unit was calibrated in our laboratory at the address shown below.


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ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD-45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.  
\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/13/2019

Signatory: Randy Atkinson

QA Approved: 

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690005

## Report of Calibration

**Manufacturer:** Interface, Inc.  
**Model:** 1220ACK-50K-B  
**Description:** Load Cell  
**Serial Number:** 1019124A

**Account Number:** 88470  
**Technician:** M. Schneider  
**Cal. Date:** 12/13/2019  
**ID:** 1019124A

### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0031	
10000	8.306	8.3018	0.010 %
20000	16.612	16.6091	0.007 %
30000	24.922	24.9249	-0.007 %
40000	33.245	33.2492	-0.010 %
50000	41.585	41.5819	0.007 %
20000	16.606	16.6091	
0	0.000	0.0031	

#### Linear Coefficients

A= 3.0714286E-03  
B= 8.2945214E-04  
C= 4.2500000E-11

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.002 VDC  
Zero Balance: 0.398 mV  
Input Resistance: 351.80 Ohms  
Output Resistance: 351.65 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30,000 kOhm	29.154 mV		35053.5 lbf	70.1 %



Report Number: 4842690005

### Report of Calibration

**Manufacturer:** Interface, Inc.  
**Model:** 1220ACK-50K-B  
**Description:** Load Cell  
**Serial Number:** 1019124A

**Account Number:** 088470  
**Technician:** M. Schneider  
**Cal. Date:** 12/13/2019  
**ID:** 1019124A

#### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0016	
10000	-8.343	-8.3398	0.008 %
20000	-16.677	-16.6769	0.000 %
30000	-25.010	-25.0132	-0.008 %
40000	-33.350	-33.3485	0.004 %
50000	-41.683	-41.6829	0.000 %
20000	-16.657	-16.6769	
0	0.000	-0.0016	

#### Linear Coefficients

A= -1.6428571E-03  
B= -8.3385786E-04  
C= 4.6428571E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.002 VDC  
Zero Balance: 0.398 mV  
Input Resistance: 351.80 Ohms  
Output Resistance: 351.65 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	- Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.112 mV		34920.7 lbf	69.8 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690010 e T



Acct #:	088470	Manufacturer:	Interface, Inc.
Customer:	MGA Research Corporation	Model:	1220AF-50K
Shipper #:	No Shipper	Description:	Load Cell
Address:	2807 Elliott	Serial Number:	305366A
	Troy, MI, 48083	Asset Number:	
Contact:	Scott Arsen	Barcode:	
PO #:	MI20037		

As Received	As Returned	Action Taken	Cal Date:	12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

Incoming Remarks:

Technical Remarks:

Calibrated with tension base torqued to 55 lb-ft mfg spec. The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of  $k=2$  unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:

ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL-STD 45662A, QD-4000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signatory: Randy Johnson

QA Approved:

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602





Report Number: 4842690010

## Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 305366A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/14/2019  
ID: 305366A

### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0004	
10000	8.261	8.2603	0.002 %
20000	16.520	16.5201	0.000 %
30000	24.780	24.7799	0.000 %
40000	33.039	33.0397	-0.002 %
50000	41.300	41.2996	0.001 %
20000	16.496	16.5201	
0	0.000	0.0004	

#### Linear Coefficients

A= 4.2857143E-04  
B= 8.2598286E-04  
C= -3.2607658E-24

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.019 mV  
Input Resistance: 350.87 Ohms  
Output Resistance: 350.87 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.064 mV		35186.4 lbf	70.4 %



Report Number: 4842690010

### Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 305366A

Account Number: 088470  
Technician: M. Schneider  
Cal. Date: 12/14/2019  
ID: 305366A

#### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0004	
10000	-8.305	-8.3064	-0.003 %
20000	-16.614	-16.6126	0.003 %
30000	-24.918	-24.9180	0.000 %
40000	-33.222	-33.2227	-0.002 %
50000	-41.527	-41.5267	0.001 %
20000	-16.609	-16.6126	
0	0.000	0.0004	

#### Linear Coefficients

A= 4.2857143E-04  
B= -8.3072143E-04  
C= 3.5714286E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.019 mV  
Input Resistance: 350.87 Ohms  
Output Resistance: 350.87 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.057 mV		34985.7 lbf	70.0 %



17025 Accredited Certificate of Calibration

Certificate #: 4842690003 e T



<b>Acct #:</b>	088470	<b>Manufacturer:</b>	Interface, Inc.
<b>Customer:</b>	MGA Research Corporation	<b>Model:</b>	1220AF-50K
<b>Shipper #:</b>	No Shipper	<b>Description:</b>	Load Cell
<b>Address:</b>	2807 Elliott Troy, MI, 48083	<b>Serial Number:</b>	305386A
<b>Contact:</b>	Scott Arsen	<b>Asset Number:</b>	
<b>PO #:</b>	MI20037	<b>Barcode:</b>	

As Received	As Returned	Action Taken	Cal Date:	12/14/2019
In Tolerance X	In Tolerance X	Full Calibration X	Due Date:	12/14/2020
Out of Tolerance	Out of Tolerance	Special Calibration	Temperature:	73.00 deg. F
Malfunctioning	Malfunctioning	Oper. Verification	Humidity:	35.00 %
Operational	Operational	Adjusted	Baro. Press.:	
Damaged	N/A	Repaired	Procedure:	DCN 50345
N/A		Charted	Reference:	ASTM E74 (2018) / local
		Returned As Is	Dept:	

**Incoming Remarks:**

**Technical Remarks:**

Tension base torqued to 55 lb-ft mfg spec before calibration  
The estimated measurement uncertainty is  $\pm 13$  lbf, which represents an expanded uncertainty using a coverage factor ( $k = 2$ ) approximating a 95 % confidence level.

**Calibration Standards Utilized**

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
4574900033	General Radio	1434-B	Decade Resistor	04/26/2019	04/26/2020
4747080039	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/22/2019	04/22/2020
4747080040	Honeywell	IC48/J345-01-	Imperial Class Load Cell	10/21/2019	10/21/2020
4747080044	Agilent Technologi	34420A	Nanovolt/Micro-Ohmmeter	10/17/2019	04/17/2020

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Trescal. This unit has been calibrated utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 approximating a 95 % confidence level with a coverage factor of  $k=2$  unless otherwise stated above or as stated on the Report of Calibration. Trescal, Inc. utilizes a simple decision rule unless otherwise specified, uncertainties are not included in Pass/Fail determination. The calibration was performed using references traceable to the SI through NIST or other recognized national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Trescal's calibration program is in compliance with:


ISO/IEC 17025:2017, ANSI/NCSL Z540-1:1994, ANSI/NCSL Z540.3:2006, MIL STD 45662A, QD-1000:2011.

Trescal warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

\* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Mark Schneider, 12/14/2019

Signatory: Randy Harrison

QA Approved: 

1200 N. Old US 23, PO Box 559, Hartland, MI 48353-0559 (810) 225-4601 FAX (810) 225-4602



Report Number: 4842690003

### Report of Calibration

Manufacturer: Interface, Inc.  
Model: 1220AF-50K  
Description: Load Cell  
Serial Number: 305386A

Account Number: 88470  
Technician: M. Schneider  
Cal. Date: 12/14/2019  
ID: 305386A

#### Calibrated in Tension

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	0.0029	
10000	8.246	8.2420	0.010 %
20000	16.485	16.4825	0.006 %
30000	24.722	24.7243	-0.005 %
40000	32.963	32.9674	-0.011 %
50000	41.215	41.2119	0.007 %
20000	16.449	16.4825	
0	0.000	0.0029	

#### Linear Coefficients

A= 2.9285714E-03  
B= 8.2384071E-04  
C= 6.7857143E-12

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC  
Zero Balance: 0.056 mV  
Input Resistance: 351.45 Ohms  
Output Resistance: 351.44 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to + Excitation	Simulated Load	Percent of FS
30.000 kOhm	29.123 mV		35330.6 lbf	70.7 %



Report Number: 4842690003

### Report of Calibration

**Manufacturer:** Interface, Inc.  
**Model:** 1220AF-50K  
**Description:** Load Cell  
**Serial Number:** 305386A

**Account Number:** 088470  
**Technician:** M. Schneider  
**Cal. Date:** 12/14/2019  
**ID:** 305386A

#### Calibrated in Compression

Applied lbf	Observed mV	Least Squares Line	Percent Error
0	0.000	-0.0012	
10000	-8.282	-8.2798	0.005 %
20000	-16.558	-16.5584	-0.001 %
30000	-24.837	-24.8370	0.000 %
40000	-33.114	-33.1155	-0.004 %
50000	-41.395	-41.3940	0.002 %
20000	-16.548	-16.5584	
0	0.000	-0.0012	

#### Linear Coefficients

A= -1.1785714E-03  
B= -8.2786607E-04  
C= 1.7857143E-13

#### Bridge Connections

(+) Excitation: A  
(+) Signal: B  
(-) Signal: C  
(-) Excitation: D

Deflections = A + (B \* Load) + (C \* Load^2)

#### Electrical Data

Excitation: 10.005 VDC      Input Resistance: 351.45 Ohms  
Zero Balance: 0.056 mV      Output Resistance: 351.44 Ohms

#### Shunt Calibration(s)

Electrical Load	Output	+ Signal to - Excitation	Simulated Load	Percent of FS
30.000 kOhm	-29.154 mV		35214.4 lbf	70.4 %



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Tel: 248-778-2000 Fax: 248-778-2001  
email: info@humaneticsatd.com  
website: www.humaneticsatd.com

## Report Summary

Automated Load Cell Calibration System  
Copyright (c)1987-2017 Humanetics Innovative Solutions, Inc. Calibration Cert # 2421.03



Customer Name:	MGA RESEARCH CORPORATION	Identification No.:	BF1910081126
	33653 DEQUINDRE	Date <sup>4</sup> :	10/8/2019
	TROY MI 48083		

Manufacturer: Humanetics  
Model Number: 9555TF

Serial Number: DH9302

### As Received Condition

In Tolerance<sup>6</sup> ☒  
Out of Tolerance<sup>6</sup> ☐  
Operational ☐  
Not Operational ☐  
Damaged ☐  
N/A ☐

### Received Notes

n/a

### As Shipped Condition

In Tolerance<sup>6</sup> ☒  
Out of Tolerance<sup>6</sup> ☐  
Operational ☐  
Not Operational ☐  
Damaged ☐  
N/A ☐

### As Shipped Notes

n/a

### Action Taken

Repair ☐  
Full Calibration ☒  
Special Calibration ☐  
Returned "As Is" ☐

### Action Notes

n/a

### Technical Notes:

Calibration A2LA Accredited: ☒ Yes ☐ No

- 1) Unless otherwise noted all calibrations conform to ISO 17025:2005.

Standard ID	Report No.	Serial No.	Due Date	CMC(8) Uncertainty (Force)	CMC(8) Uncertainty (Moment)
2K-CL-D2K- 1	a912829cf3a74d4fa1c9	571308	3/7/2020	0.20% F.S.	0.50% F.S.

- 2) Calibration Standards Used: Standards used in the calibration of this transducer are traceable to NIST (National Institute of Standards and Technology). With exception of the measurements reported on the Load Cell Bridge Impedance Measurement Summary, which are for verification only.
- 3) Laboratory Scope: Humanetics Innovative Solution, Inc.'s calibration program is accredited to ISO/IEC 17025:2005 ANSI/NCCL Z-540-1-1994.
- 4) "Date" indicates confirmation of calibration data and should be used to increment calibration intervals.
- 5) Calibration Methods: The Calibration Methods used in this calibration are defined in the Calibration Method for Single and Multi-Axis Load Cells (CL-WI-00002P). Procedure Number: CL-PR-00001P/CL-PR-00002P.
- 6) This document applies only to the calibration of the item described above and the specific calibration performed by the Humanetics Innovative Solutions, Inc. calibration laboratory. When declaring In Tolerance or Out of Tolerance conditions(s), the calibration laboratory utilizes a Shared Risk Method\*\* as the decision rule. The stability of the UUT over time depends on many factors outside our control. It is the responsibility of those using the item described above to quantify their measurement of uncertainty and evaluate the adequacy of their measurement process to demonstrate that measurement traceability is credibly maintained.
- 7) This report shall not be reproduced, except in full, without the written consent of the Humanetics Innovative Solutions, Inc.'s calibration laboratory.
- 8) Calibration and Measurement Capabilities (CMC) represent expanded uncertainties expressed at approximately the 95% level of confidence, coverage factor of  $k = 2$ .

\*\*The Humanetics Innovative Solutions, Inc. calibration laboratory does not expand the provided measured value(s) by the associated uncertainty of the measurement. When parameter(s) are certified to be within specified tolerance(s), the unexpanded measured value(s) shall fall within the appropriate specification limit. With written agreement from the customer, other decision rules may be used. Please visit the company website at [www.humaneticsatd.com](http://www.humaneticsatd.com) for a copy of the Scope and Certificate. A copy of the scope and certificate is also available upon request.

*10/10/19*



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email: info@humaneticsatd.com  
website: www.humaneticsatd.com

## Calibration Report Uni-Directional Calibration

Automated Load Cell Calibration System  
Copyright (c)1987-2017 Humanetics Innovative Solutions, Inc.

Applied Excitation (VDC)	10.000	Date	10/8/2019
Calibration No.	BF1910081126	6 Mo. From Cal	4/8/2020
Model No.	9555TF	12 Mo. From Cal	10/8/2020
Technician	BURCHI	Serial No.	DH9302
Customer	MGA RESEARCH CORPORATION	Temp (°C)	23.1
Description	3-Channel Load Cell	Last Calibrated	Hum. (%) 37.9
		Customer Tag Number	10/10/2018

### Voltage Calibration

Bridge	Capacity	Zero Offset	Nonlinearity	Hysteresis	Output @ Capacity	% Change
FX	2224.1 N	-0.0025 mV/V	0.02 % FS	0.18 % FS	1.7147 mV/V	0.16 % FS
FY	2224.1 N	0.0064 mV/V	0.06 % FS	0.21 % FS	1.7183 mV/V	0.09 % FS
FZ	4448.2 N	0.0199 mV/V	0.05 % FS	0.04 % FS	-1.2413 mV/V	0.18 % FS

### Calculated Sensitivity Matrix

Bridge	Capacity	N	Using Sensor @ 10 V Excitation		Using Sensor @ 5V Excitation		Using Sensor @ 2V Excitation	
			Output mV @ Capacity	Output mV/EU	Output mV @ Capacity	Output mV/EU	Output mV @ Capacity	Output mV/EU
FX	2224.1	N	17.1465	0.00770938	8.5733	0.00385469	3.4293	0.00154188
FY	2224.1	N	17.1830	0.00772580	8.5915	0.00386290	3.4366	0.00154516
FZ	4448.2	N	-12.4128	-0.00279050	-6.2064	-0.00139525	-2.4826	-0.00055810

### Shunt

Bridge	Shunt Value	Equivalent Load	Bridge Resistance (nom)
FX	150.0 K Ohms	1529.0 N	700.0 Ohms
FY	150.0 K Ohms	1527.0 N	700.0 Ohms
FZ	200.0 K Ohms	3162.0 N	700.0 Ohms

Note: Positive shunt is between +Exc\_+Sig Negative shunt is between -Exc\_+Sig

### Wire Color Codes

FX		FY		FZ	
Bm	+ Exc	Red Stp	+ Exc	Grn	+ Exc
Red	+ Sig	Blk	+ Sig	Blu	+ Sig
N/A	+ Teds	N/A	+ Teds	N/A	+ Teds
Org	- Exc	Wht	- Exc	Vio	- Exc
Yel	- Sig	Blk Stp	- Sig	Gry	- Sig
N/A	- Teds	N/A	- Teds	N/A	- Teds

### Reference Load Cell

Standard ID	Manufacturer	Model No.	Serial No.	Report No.	Calibration Due Date
2K-CL-D2K-1	Interface, Inc.	1610FMO-2K-T	571308	a912829cf3a74d4fa1c9	3/7/2020

Calibrated by:

Humanetics Innovative Solutions, Inc. Authorized Representative

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Tel: 248-778-2000 Fax: 248-778-2001  
email: info@humaneticsatd.com  
website: www.humaneticsatd.com

## Loading Sequence Summary Uni-Directional Calibration

Automated Load Cell Calibration System  
Copyright (c)1987-2017 Humanetics Innovative Solutions, Inc.

Calibration Number	BF1910081126	Date	10/8/2019	
Model Number	9555TF	6 Mo. From Cal	4/8/2020	12 Mo. From Cal 10/8/2020
Serial Number	DH9302	Last Calibrated	10/10/2018	
Description	3-Channel Load Cell	Temp (°C)	23.1	Hum. (%) 37.9
Customer	MGA RESEARCH CORPORATION	Customer Tag Number		

### Loading Sequence

Axis	FS Load EU	FS Output mV/V	Sensitivity mV/V/EU	Nonlinearity % FS	Hysteresis % FS	Moment Arm EU
FX	2224.1 N	1.714651	0.00077094	0.02	0.18	0
FY	2224.1 N	1.718303	0.00077258	0.06	0.21	0
FZ	4448.2 N	-1.241278	-0.00027905	0.05	0.04	0

### Bridge Unbalance

FX Axis	0.0012 mV/V
FY Axis	0.0015 mV/V
FZ Axis	0.0001 mV/V

### Linearization

Force (	FX	)	=	-0.05	+	1297.22	*	Output (mV/V)
Force (	FY	)	=	-0.57	+	1294.74	*	Output (mV/V)
Force (	FZ	)	=	-1.04	+	-3583.17	*	Output (mV/V)

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## Crosstalk Summary Uni-Directional Calibration

Automated Load Cell Calibration System  
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Calibration Number	BF1910081126	Date	10/8/2019
Model Number	9555TF	6 Mo. From Cal	4/8/2020
Serial Number	DH9302	12 Mo. From Cal	10/8/2020
Description	3-Channel Load Cell	Last Calibrated	10/10/2018
Customer	MGA RESEARCH CORPORATION	Temp (°C)	23.1
		Hum. (%)	37.9
		Customer Tag Number	

### Crosstalk Data (mV/V)

<u>Bridge</u>	<u>Applied Load</u>	<u>FX</u>	<u>FY</u>	<u>FZ</u>			
FX	2224.1 N	1.714651	-0.006162	0.001837	0.000000	0.000000	0.000000
FY	2224.1 N	0.009423	1.718303	-0.002300	0.000000	0.000000	0.000000
FZ	4448.2 N	0.001186	0.000697	-1.241278	0.000000	0.000000	0.000000

### % FS Crosstalk \*

<u>Bridge</u>	<u>Applied Load</u>	<u>FX</u>	<u>FY</u>	<u>FZ</u>			
FX	2224.1 N	0.0000%	-0.3586%	-0.1480%	0.0000%	0.0000%	0.0000%
FY	2224.1 N	0.5496%	0.0000%	0.1853%	0.0000%	0.0000%	0.0000%
FZ	4448.2 N	0.0692%	0.0406%	0.0000%	0.0000%	0.0000%	0.0000%

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\* Percentage crosstalk for force channels applying moments are corrected for the applied force



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website: www.humaneticsatd.com

## Measurement Report Load Cell Bridge Impedance Measurement Summary

Automated Load Cell Calibration System

Copyright (c)1987-2017 Humanetics Innovative Solutions Inc.

Calibration Number	BF1910081126	Date	10/8/2019
Model Number	9555TF	6 Mo. From Cal	4/8/2020
Serial Number	DH9302	12 Mo. From Cal	10/8/2020
Description	3-Channel Load Cell	Last Calibrated	10/10/2018
Customer	MGA RESEARCH CORPORATION	Temp (°C)	23.1
		Hum. (%)	37.9
		Customer Tag	

### Bridge Impedance Measurements\*

Axis	Input Impedance	Output Impedance	
Channel 1 FX	706.0	706.1	Ohms
Channel 2 FY	704.3	706.0	Ohms
Channel 3 FZ	706.1	704.3	Ohms

### Bridge High Short Measurement\*\*

Axis	Bridge to Transducer Body
Channel 1 FX	>=2.00G Ohms (10 <sup>9</sup> Ohms)
Channel 2 FY	>=2.00G Ohms (10 <sup>9</sup> Ohms)
Channel 3 FZ	>=2.00G Ohms (10 <sup>9</sup> Ohms)

#### Measurement Equipment

National Instruments PXI-4071 Multimeter  
Keysight B2985A Electrometer/High Resistance Meter

#### Measurement Accuracy

$\pm((0.0048 \times \text{reading}) + 0.05 \text{ Ohms})/2 \text{ Years @ } 18 \text{ to } 28^\circ\text{C}$   
 $\pm((0.45 \times \text{reading}) + 10^4 \text{ Ohms})/\text{Year @ } 23^\circ\text{C} \pm 5^\circ\text{C}$

\*NOTE: Input impedance measurements taken between  $\pm$ excitation, output impedance measurements taken between  $\pm$ signal.

\*\*NOTE: High short measurements are taken between  $\pm$ excitation and the transducer body. Measurements are made at +50.0 VDC.  
The measurements reported on this page are for verification purposes only and are not A2LA accredited.

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35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

## Calibration Certificate



Certificate # Z63778:308340

### PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

QA Signature:

Date: 3/18/2020 10:28:14 AM



## Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003



Certificate # Z63778:308340

### PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCCL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

QA Signature:

Date: 3/18/2020 10:26:55 AM



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

## Report Of Calibration



### PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	308340
ASSET NUMBER:	Z63778	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00173	PERFORMED ON:	03/16/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	03/16/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	26 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

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This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

REMARKS: N/A

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2076	2076:1438783344	42280 - EXTECH - DATA LOGGER	09/27/2019	09/27/2020
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

### Test Procedure Results

Test results for calibration with work order : 308340

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
LINEARITY CHECK							
0° REFERENCE	0.0	0.0	-0.1	0.1	"		Pass
5°	5.0	4.9	4.9	5.1	"	0.062" + 0.6R	Pass
30°	30.0	29.8	29.8	30.2	"	0.062" + 0.6R	Pass
60°	60.0	60.0	59.8	60.2	"	0.062" + 0.6R	Pass
90°	90.0	89.9	89.9	90.1	"	0.062" + 0.6R	Pass
60°	60.0	60.0	59.8	60.2	"	0.062" + 0.6R	Pass
30°	30.0	29.9	29.8	30.2	"	0.062" + 0.6R	Pass
5°	5.0	4.9	4.9	5.1	"	0.062" + 0.6R	Pass
0°	0.0	0.1	-0.1	0.1	"		Pass
5°	5.0	5.0	4.9	5.1	"	0.062" + 0.6R	Pass
30°	30.0	29.9	29.8	30.2	"	0.062" + 0.6R	Pass
60°	60.0	59.9	59.8	60.2	"	0.062" + 0.6R	Pass
90°	90.0	90.0	89.9	90.1	"	0.062" + 0.6R	Pass
60°	60.0	59.9	59.8	60.2	"	0.062" + 0.6R	Pass
30°	30.0	30.0	29.8	30.2	"	0.062" + 0.6R	Pass
5°	5.0	5.1	4.9	5.1	"	0.062" + 0.6R	Pass
0°	0.0	0.1	-0.1	0.1	"		Pass
ABSOLUTE ZERO ANGLE	0.0	0.1	-0.1	0.1	"		Pass

- END OF REPORT -



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

## Calibration Certificate



Certificate # Z106680:312657

### 33-215 - STANLEY - 12' TAPE MEASURE

SERIAL NUMBER:	N/A	WORK ORDER:	312657
ASSET NUMBER:	Z106680	TEST RESULT:	PASS
CUST ASSET NUMBER:	TPM003-86	PERFORMED ON:	04/29/20
PROCEDURE NAME:	STA - 33-215 - MMC	CAL DUE DATE:	04/29/21
PROCEDURE REV:	1.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Anthony Barbera	TEMPERATURE:	20 °C
CUSTOMER:	MGA RESEARCH CORP 2927B ELLIOT AVENUE TROY, MI 48063	HUMIDITY:	41 %
PRIMARY CONTACT:	MATT EJAK		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCCL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

AS RECEIVED CONDITION:	Other (See Remark)	REMARKS:	Manufacturers specs not available, data charted for customers use.
AS RETURNED CONDITION:	Other (See Remark)		
ACTION TAKEN:	DATA CHARTED		

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1606	1606:1193650836	C635-1800 - L.S. STARRETT - STEEL RULE	04/26/2013	04/26/2028
2077	2077:1438783393	42280 - EXTECH - DATA LOGGER	09/12/2019	09/12/2020

QA Signature: *je McConaughay* Date: 4/29/2020 7:30:28 PM

5/5/2020  
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35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

## Report Of Calibration



### 33-215 - STANLEY - 12' TAPE MEASURE

SERIAL NUMBER:	N/A	WORK ORDER:	312657
ASSET NUMBER:	Z106680	TEST RESULT:	PASS
CUST ASSET NUMBER:	TPM003-86	PERFORMED ON:	04/29/20
PROCEDURE NAME:	STA - 33-215 - MMC	CAL DUE DATE:	04/29/21
PROCEDURE REV:	1.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Anthony Barbera	TEMPERATURE:	20 °C
CUSTOMER:	MGA RESEARCH CORP 2927B ELLIOT AVENUE TROY, MI 48063	HUMIDITY:	41 %
PRIMARY CONTACT:	MATT EJAK		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCCL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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REMARKS: Manufacturers specs not available, data charted for customers use.

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1606	1606:1193650836	C635-1800 - L.S. STARRETT - STEEL RULE	04/26/2013	04/26/2028
2077	2077:1438783393	42280 - EXTECH - DATA LOGGER	09/12/2019	09/12/2020



### **Test Procedure Results**

Test results for calibration with work order : 312657

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
3500mm TAPE MEASURE							
700mm	700	700	N/A	N/A	mm	1.0E-2 m	Pass
1400mm	1400	1400	N/A	N/A	mm	1.0E-2 m	Pass
2100mm	2100	2100	N/A	N/A	mm	1.0E-2 m	Pass
2800mm	2800	2800	N/A	N/A	mm	1.0E-2 m	Pass
3500mm	3500	3500	N/A	N/A	mm	1.0E-2 m	Pass

- END OF REPORT -



## Calibration Certificate



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003



Certificate # Z66550:291742

### IMADA DS2-110 DIGITAL FORCE GAGE

SERIAL NUMBER:	297462	WORK ORDER:	291742
ASSET NUMBER:	Z66550	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00975	PERFORMED ON:	11/20/19
PROCEDURE NAME:	Force Gage	CAL DUE DATE:	11/20/20
PROCEDURE REV:	4.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	WILLIAM FRENCH	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	31 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCCL Z540-1-1994.

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For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1633	1633:1193663229	RICE LAKE CLASS 6 17 PC. WEIGHT SET	07/16/2019	07/16/2020
1960	1960:1324551206	RICE LAKE CLASS 6 5 PC. WEIGHT SET	01/31/2019	01/31/2020
2116	2116:1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020
2201	529030000003900	RICELAKE CLASS 6 11 PIECE WEIGHT SET	05/16/2019	05/16/2020

QA Signature: *je McConaghay* Date: 11/20/2019 9:56:07 AM



35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

## Report Of Calibration



### IMADA DS2-110 DIGITAL FORCE GAGE

SERIAL NUMBER:	297462	WORK ORDER:	291742
ASSET NUMBER:	Z66550	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00975	PERFORMED ON:	11/20/19
PROCEDURE NAME:	Force Gage	CAL DUE DATE:	11/20/20
PROCEDURE REV:	4.0	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	WILLIAM FRENCH	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - STATIC LAB 33653 DEQUINDRE TROY, MI 48083	HUMIDITY:	31 %
PRIMARY CONTACT:	Takisha Doss		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

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REMARKS: N/A

### Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1633	1633:1193663229	RICE LAKE CLASS 6 17 PC. WEIGHT SET	07/16/2019	07/16/2020
1960	1960:1324551206	RICE LAKE CLASS 6 5 PC. WEIGHT SET	01/31/2019	01/31/2020
2116	2116:1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020
2201	529030000003900	RICELAKE CLASS 6 11 PIECE WEIGHT SET	05/16/2019	05/16/2020

### Test Procedure Results

Test results for calibration with work order : 291742

Test Description	Nominal	Test Result	Limit (Lower)	Limit (Upper)	Units	Uncertainty	Pass/Fail
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UUT range is 0 - 110 LBS

UUT Tolerance is  $\pm 0.2\% + 0.1\text{LBS}$

Local gravity correction factor is 0.999662

#### Tension

0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass
21.99LBS	21.99	22.1	21.7	22.3	Lbs	7.2e-002	Pass
43.99LBS	43.99	44.1	43.7	44.3	Lbs	7.4e-002	Pass
65.98LBS	65.98	66.1	65.7	66.3	Lbs	7.7e-002	Pass
87.97LBS	87.97	88.1	87.7	88.3	Lbs	7.9e-002	Pass
109.96LBS	109.96	110.0	109.6	110.3	Lbs	8.1e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
65.98LBS	65.98	66.0	65.7	66.3	Lbs	7.7e-002	Pass
43.99LBS	43.99	43.9	43.7	44.3	Lbs	7.4e-002	Pass
21.99LBS	21.99	21.9	21.7	22.3	Lbs	7.2e-002	Pass
0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass

#### Compression

0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass
21.99LBS	21.99	22.0	21.7	22.3	Lbs	7.2e-002	Pass
43.99LBS	43.99	44.0	43.7	44.3	Lbs	7.4e-002	Pass
65.98LBS	65.98	66.0	65.7	66.3	Lbs	7.7e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
109.96LBS	109.96	110.0	109.6	110.3	Lbs	8.1e-002	Pass
87.97LBS	87.97	88.0	87.7	88.3	Lbs	7.9e-002	Pass
65.98LBS	65.98	65.9	65.7	66.3	Lbs	7.7e-002	Pass
43.99LBS	43.99	43.9	43.7	44.3	Lbs	7.4e-002	Pass
21.99LBS	21.99	21.9	21.7	22.3	Lbs	7.2e-002	Pass
0.5LBS	0.50	0.5	0.2	0.8	Lbs	7.0e-002	Pass

#### Metric

##### Tension

49.880 kg	49.880	49.90	49.77	49.99	kg	8.1e-002	Pass
489.10 N	489.10	489.3	488.0	490.2	N	8.1e-002	Pass

##### Compression

49.88kg	49.880	49.90	49.77	49.99	kg	8.1e-002	Pass
489.10 N	489.10	489.3	488.0	490.2	N	8.1e-002	Pass

- END OF REPORT -

# Calibration Certificate

Certificate # G19Q7-001.14

Calibration Date 2020-01-02  
BY 1111111111

Model: Digital Terminal  
Serial #: G19Q7-001.14

## Measurement Standards Traceability

Standard	Serial Number	Calibration Due Date	Calibration Due Date	Calibration Due Date
1. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
2. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
3. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
4. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
5. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
6. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
7. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
8. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
9. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021
10. NIST Standard	4519	11/11/2021	11/11/2021	11/11/2021

The calibration standards have been calibrated with a device traceable to the International System of Units (SI) through a National Accredited Institute (NIST) Accredited Laboratory.

## Calibration Results

Item	Specification	Measurement	Result
1. Single Point Accuracy	±0.005, 20°C-25°C and ±0.010, 25°C-30°C	0.005	PASSED
2. Linearity	±0.005, 20°C-25°C and ±0.010, 25°C-30°C	0.005	PASSED
3. Repeatability	±0.005, 20°C-25°C and ±0.010, 25°C-30°C	0.005	PASSED

## Instrument Calibration Information (AS FOUND)

This certificate indicates all other certificates generated before: 2020-01-02 8:01:25 AM  
This certificate shall not be reproduced, except in full, without permission of FARO Technologies, Inc.  
The results of this certificate relate only to the items calibrated or tested.  
Calibration Standard Used: ASME B89.4.22-2004.

FARO Technologies Inc.  
PH11-400-755-2771  
PH2-400-755-2771  
PH3-400-755-2771  
PH4-400-755-2771

125 Technology Park  
Lake Mary, FL 32746  
USA

Approved by Technician: 1111111111  
Date: 2020-01-02

Instrument calibration performed (AS FOUND)  
Within specifications.

11/11/2021



Cal # 1111111111 Calibration

# FARO®

## 5.0 Photographs



2020 BMW 3-Series  
NHTSA No. C20204100

Front view of vehicle  
Before testing

FMVSS No. 216a



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

3/4 right front view of vehicle  
Before testing





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Right view of vehicle  
Before testing





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Right side interior front seating area  
Before testing



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

3/4 right rear view of vehicle  
Before testing



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Rear view of vehicle  
Before testing





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

3/4 left rear view of vehicle  
Before testing



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Left view of vehicle  
Before testing



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Left side interior front seating area  
Before testing



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

3/4 left front view of vehicle  
Before testing





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 1





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 2



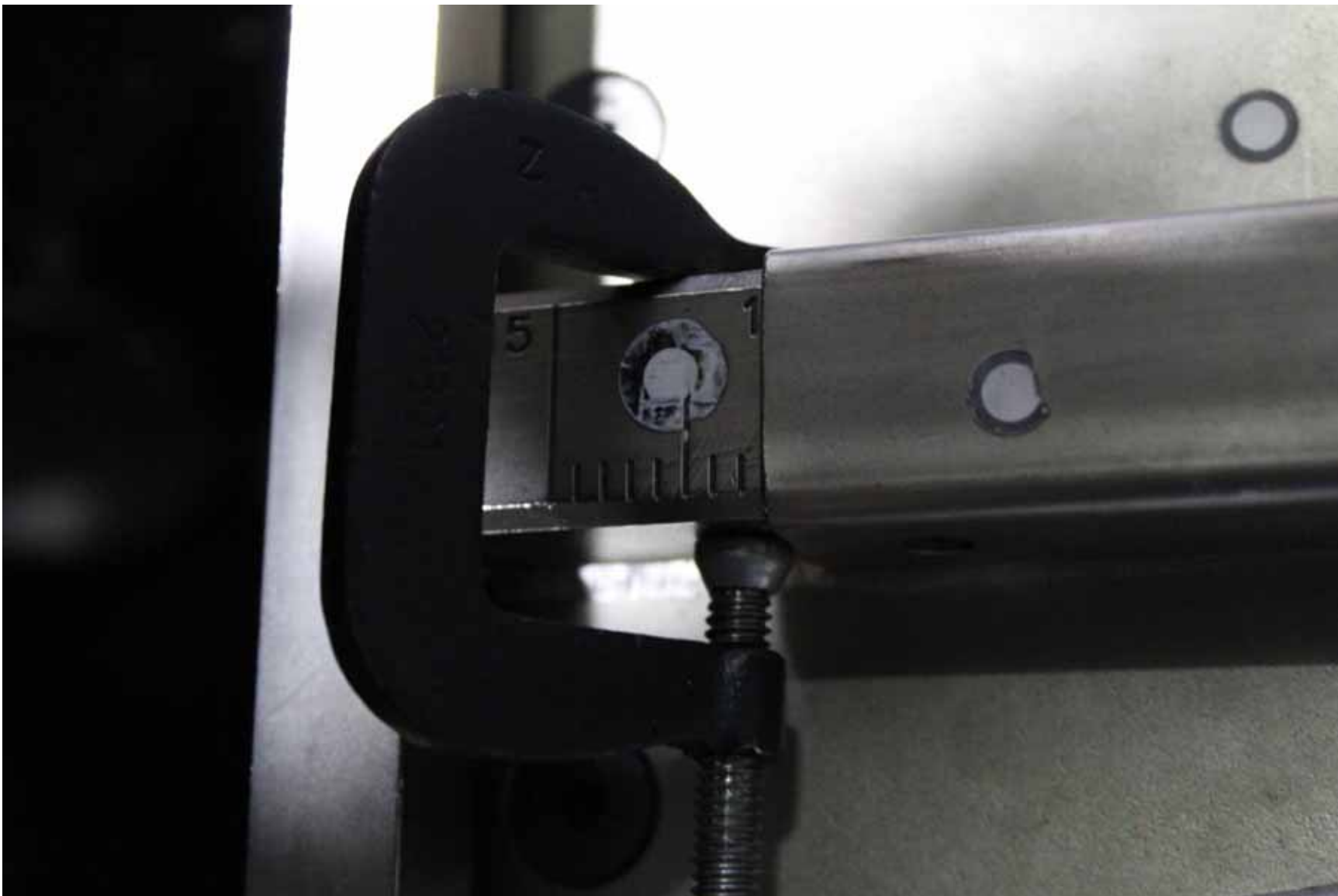
2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 3



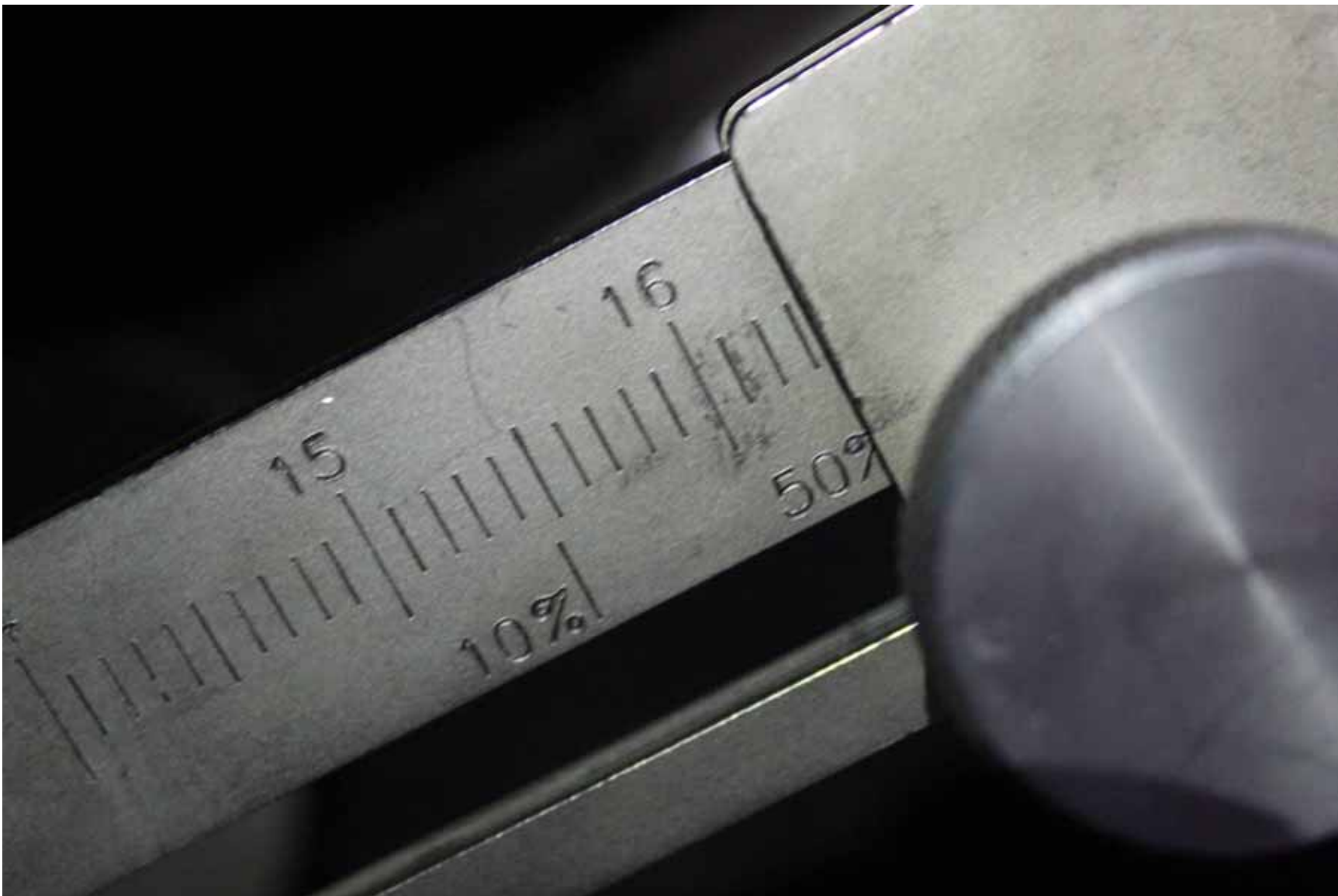
2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 4



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

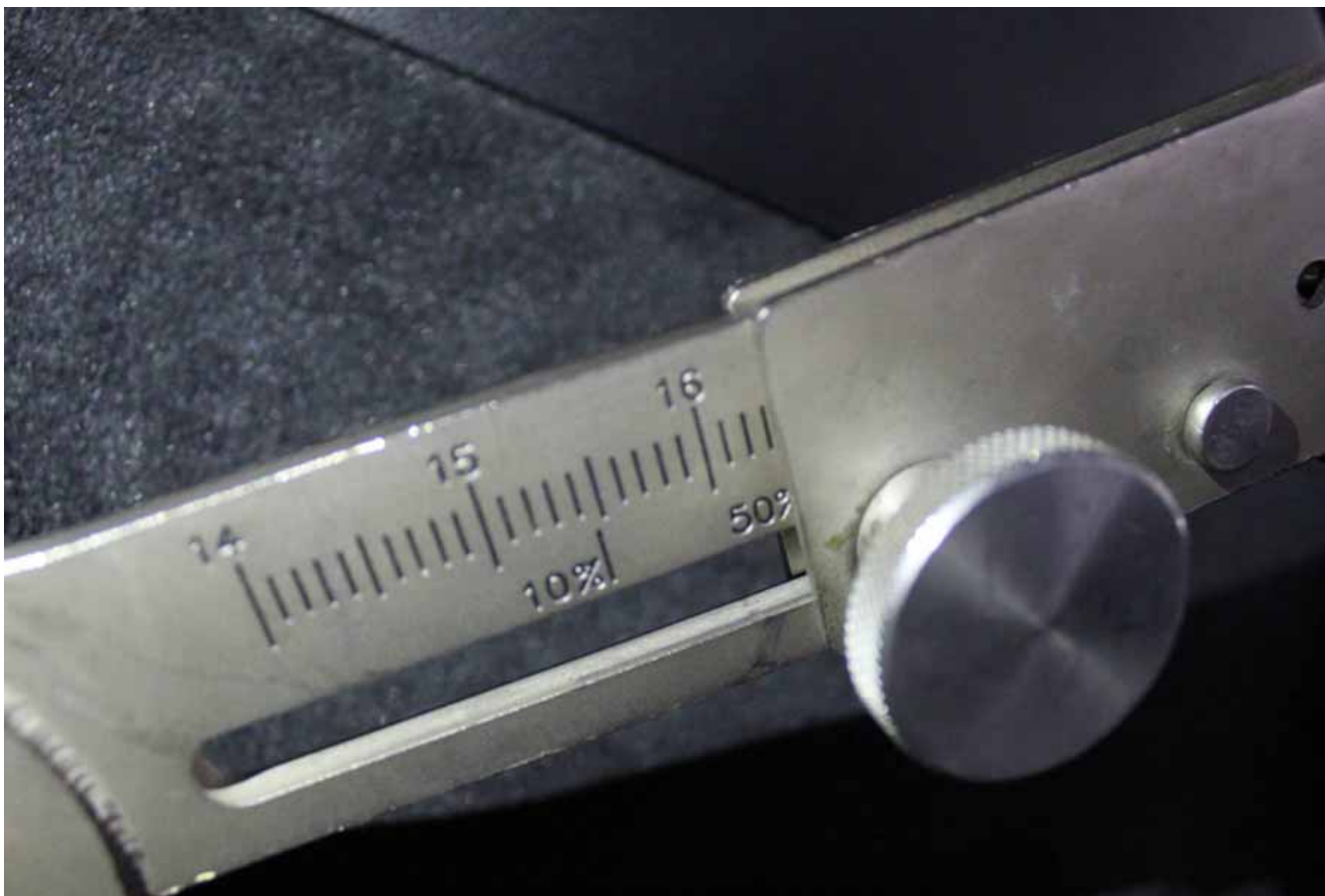
Driver Side Oscar Photograph No. 5



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

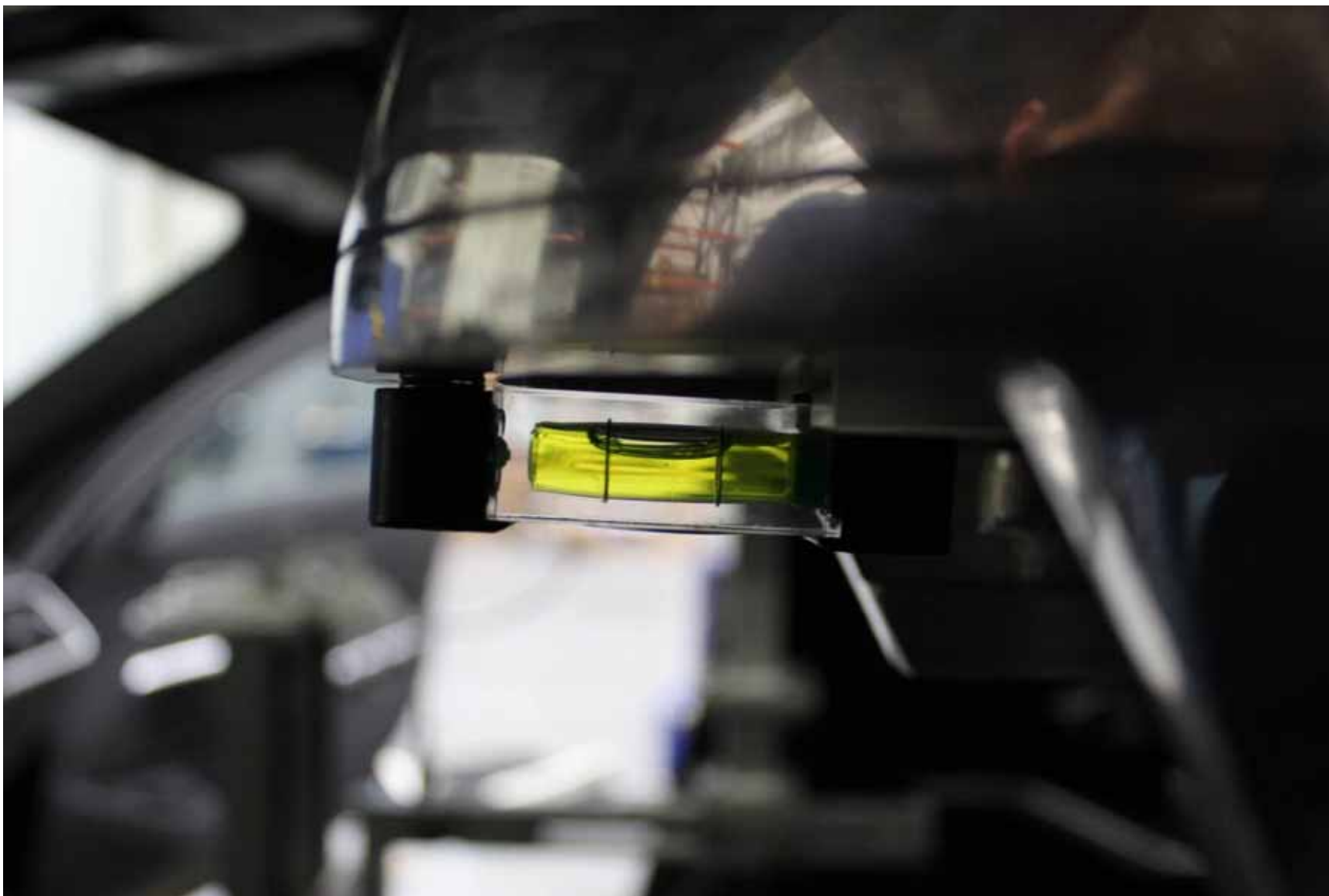
Driver Side Oscar Photograph No. 6





2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 7



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Driver Side Oscar Photograph No. 8



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Passenger Side Oscar Photograph No. 1





2020 HYUN BMW DAI 3-Series  
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Passenger Side Oscar Photograph No. 2



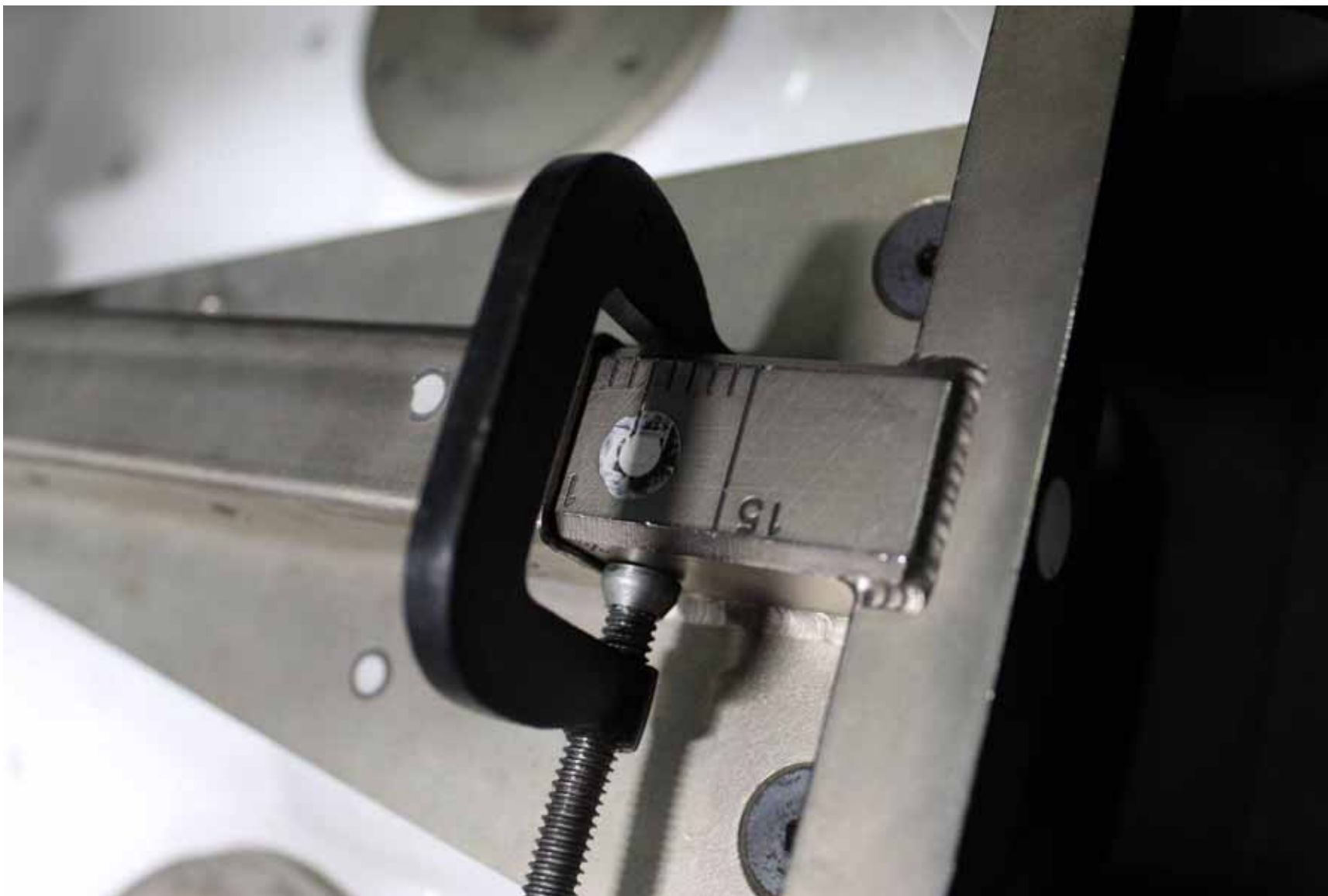
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Passenger Side Oscar Photograph No. 4



2020 BMW 3-Series  
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Passenger Side Oscar Photograph No. 5





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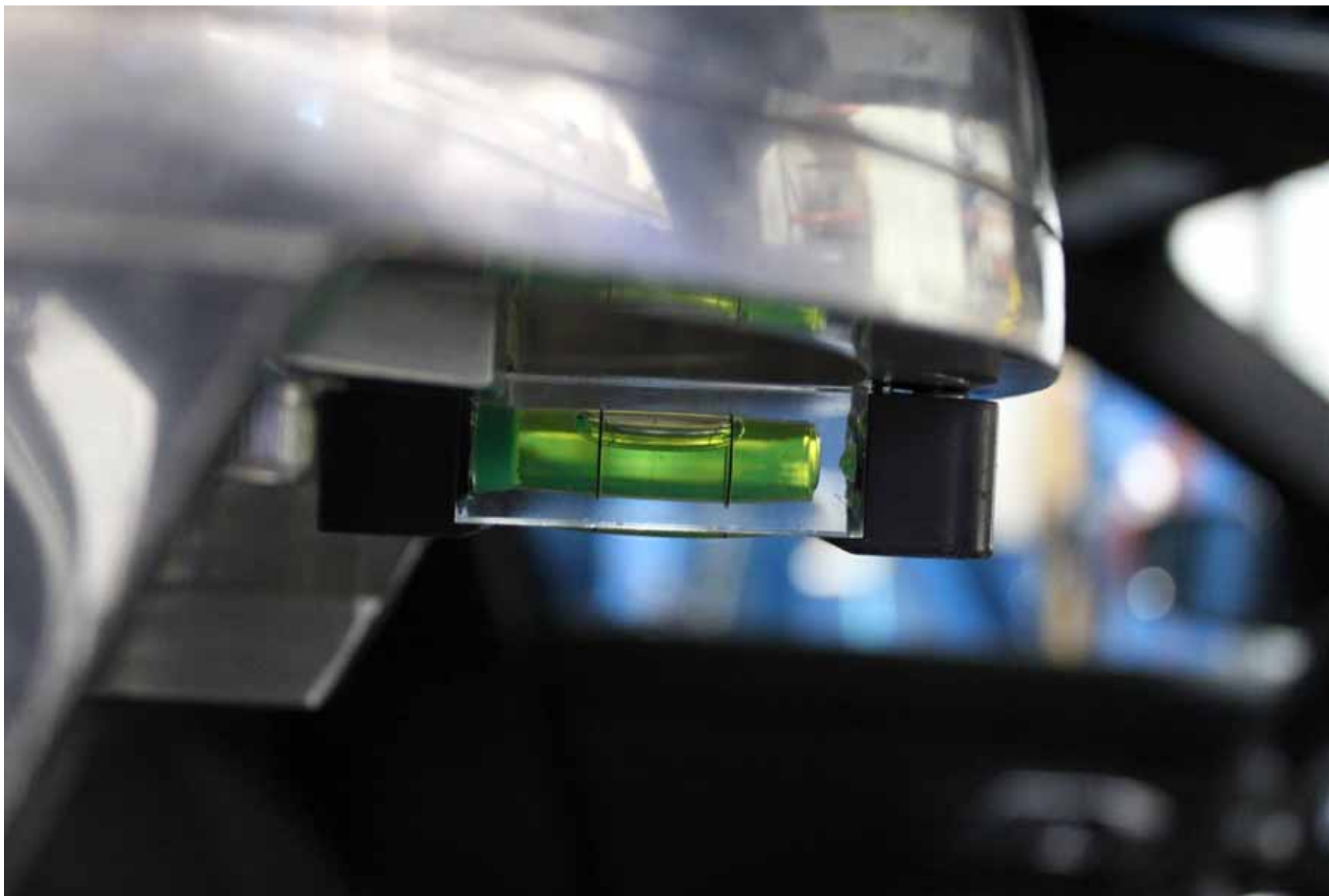
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Passenger Side Oscar Photograph No. 8



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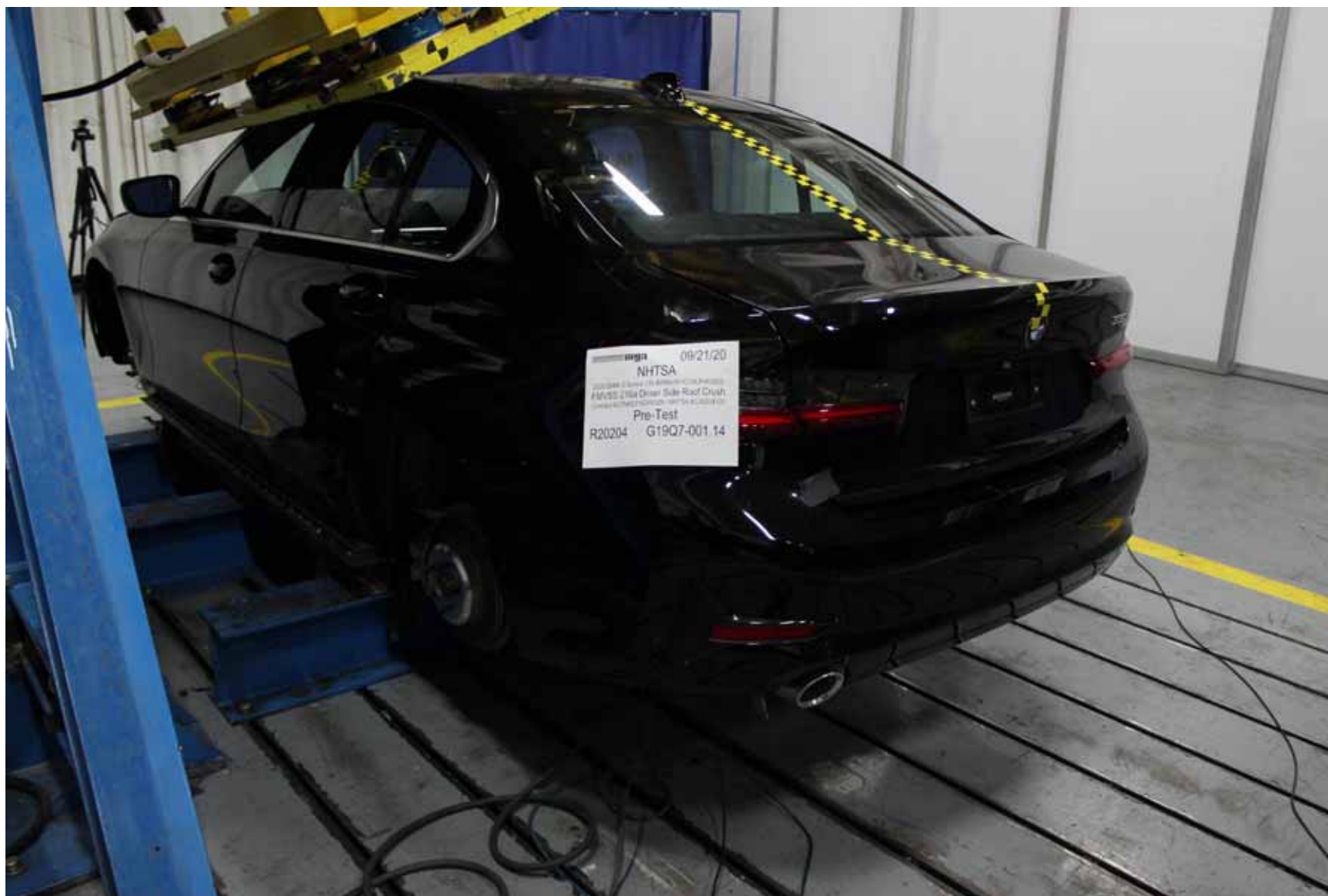
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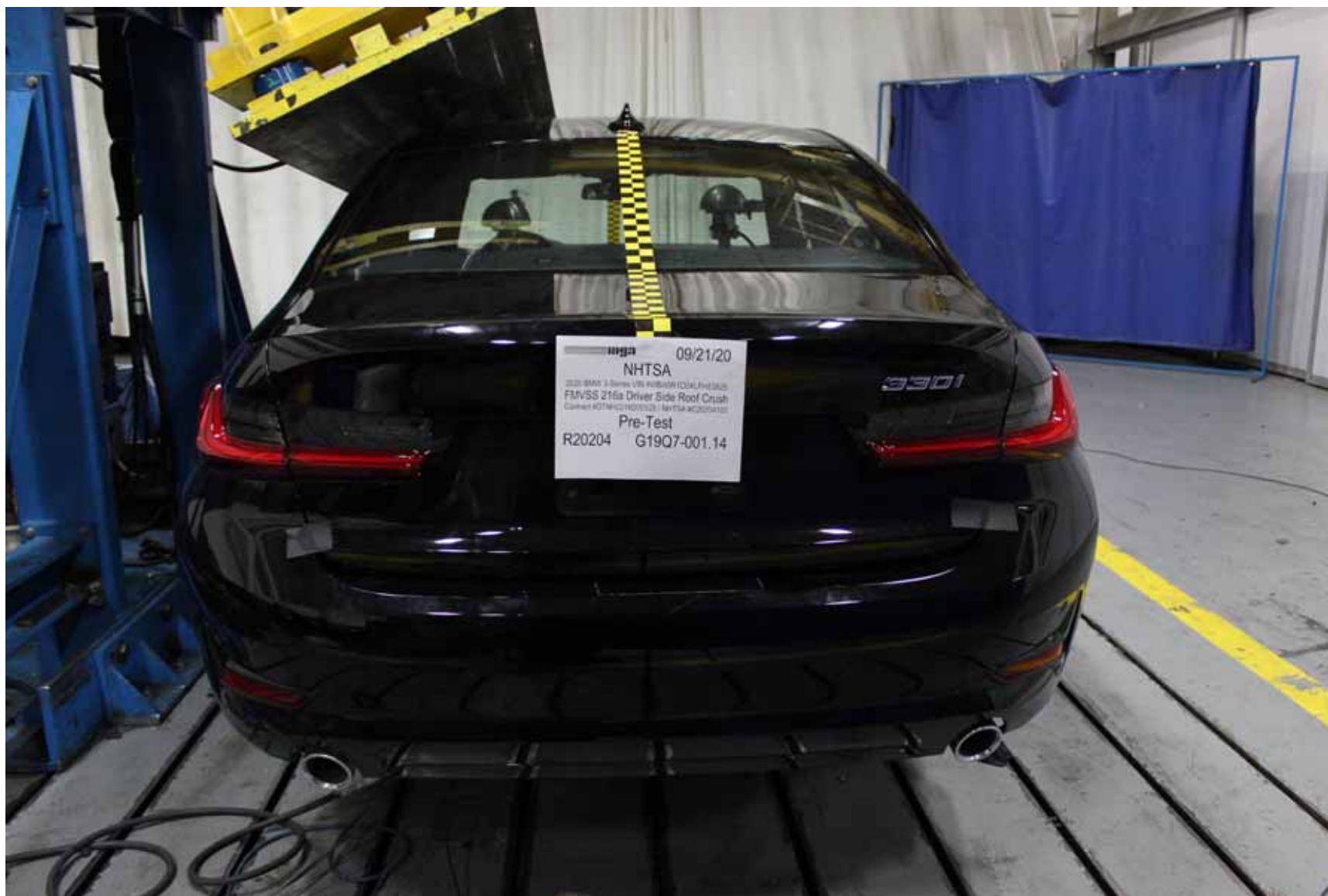
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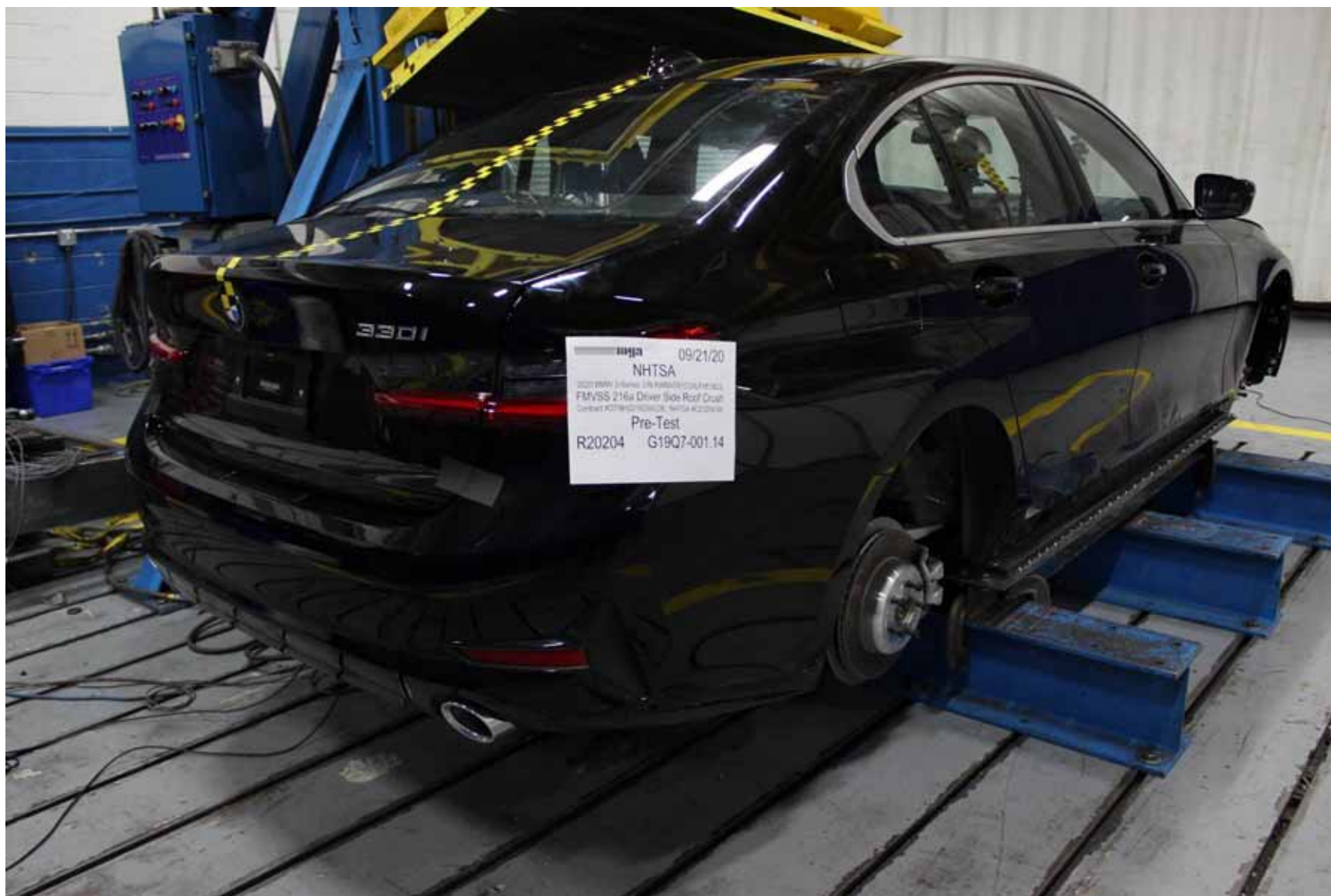
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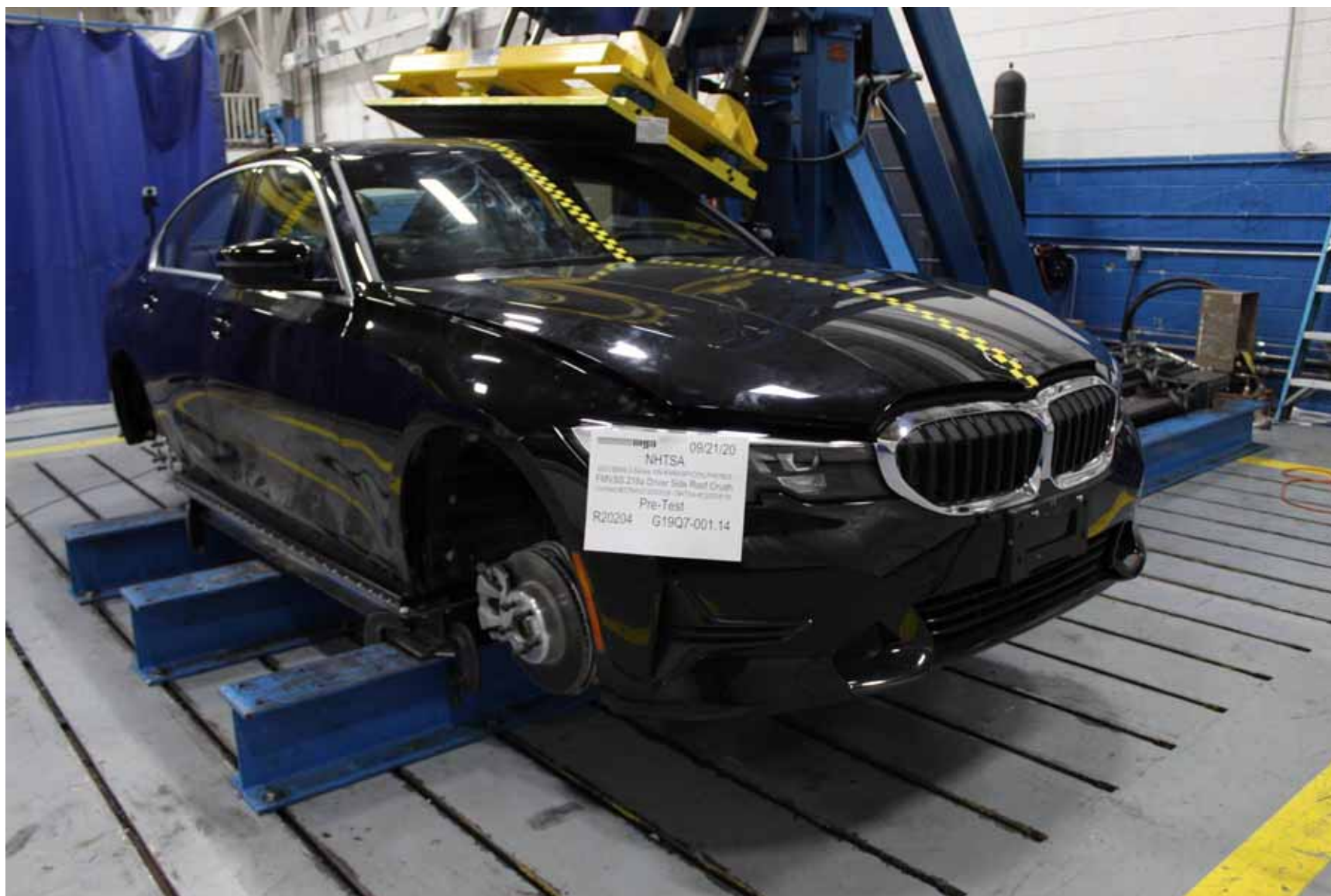
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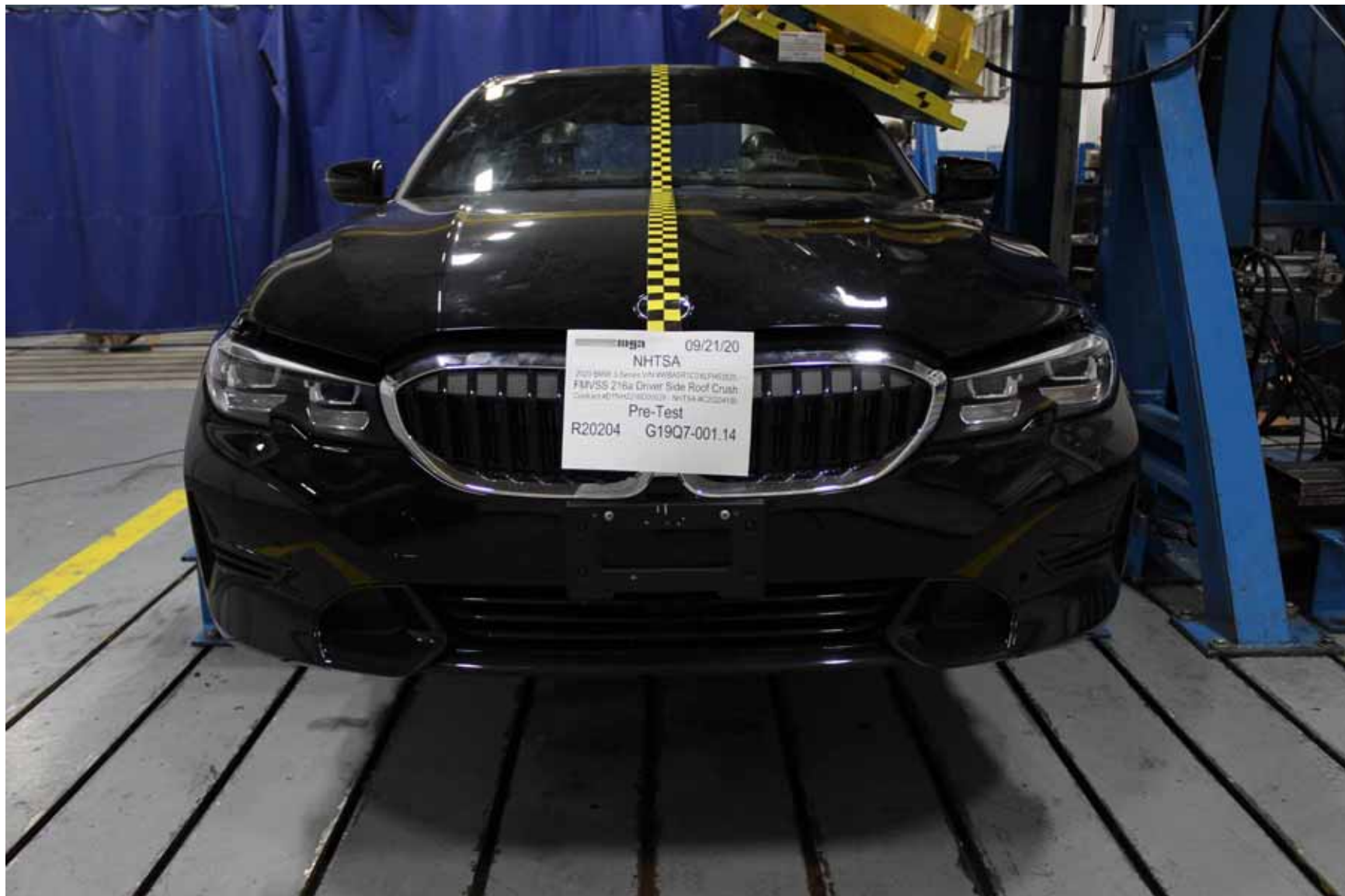




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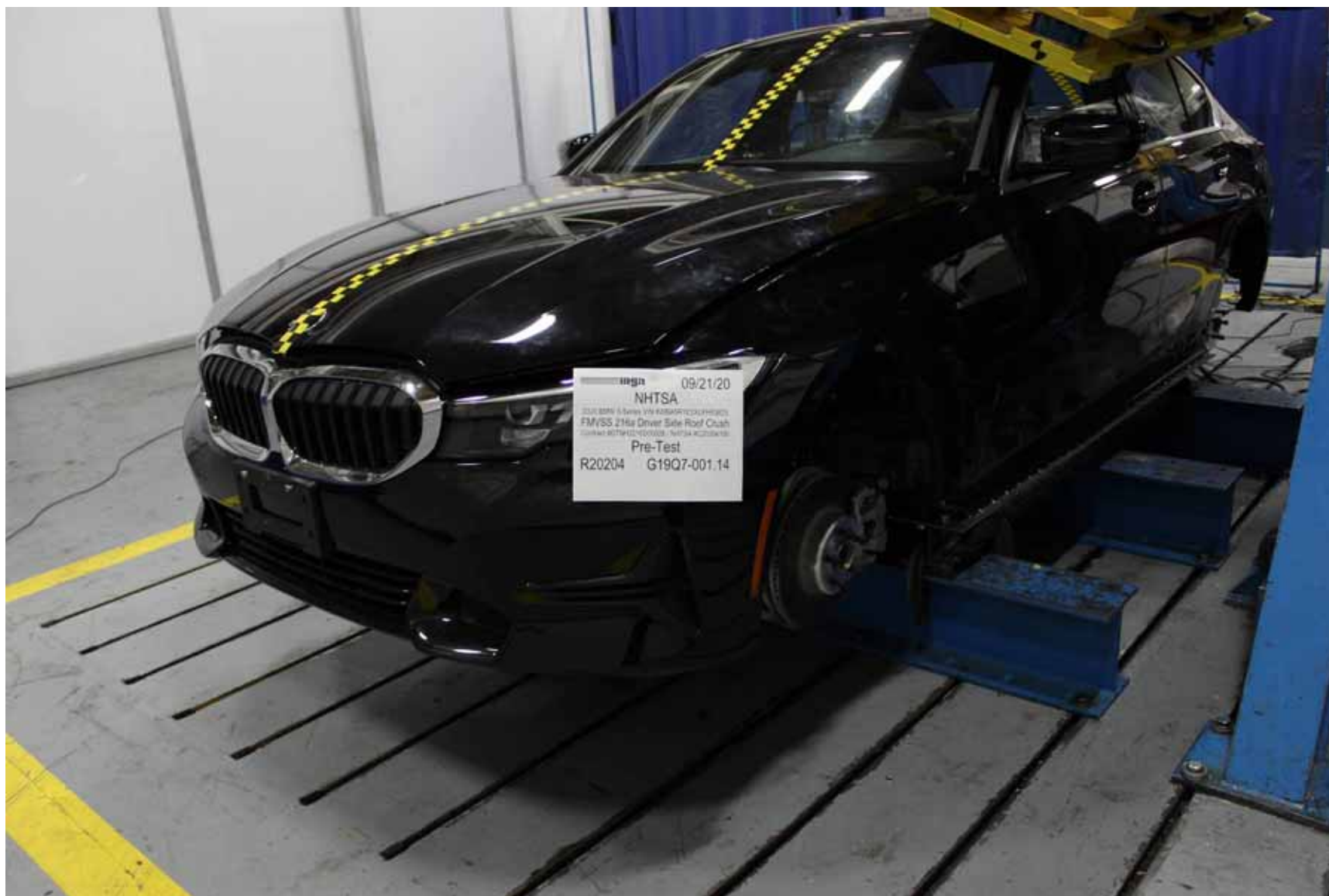
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FMVSS No. 216a

Pre-Test Photograph No. 8 of Test R20204



2020 BMW 3-Series  
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Pre-Test Photograph No. 9 of Test R20204





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Pre-Test Photograph No. 10 of Test R20204



2020 BMW 3-Series  
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Pre-Test Photograph No. 11 of Test R20204





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Pre-Test Photograph No. 12 of Test R20204



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FMVSS No. 216a

Pre-Test Photograph No. 13 of Test R20204



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FMVSS No. 216a

Pre-Test Photograph No. 14 of Test R20204





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FMVSS No. 216a

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FMVSS No. 216a

Pre-Test Photograph No. 16 of Test R20204



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NHTSA No. C20204100

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FMVSS No. 216a



2020 BMW 3-Series  
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Pre-Test Photograph No. 18 of Test R20204





2020 BMW 3-Series  
NHTSA No. C20204100

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FMVSS No. 216a



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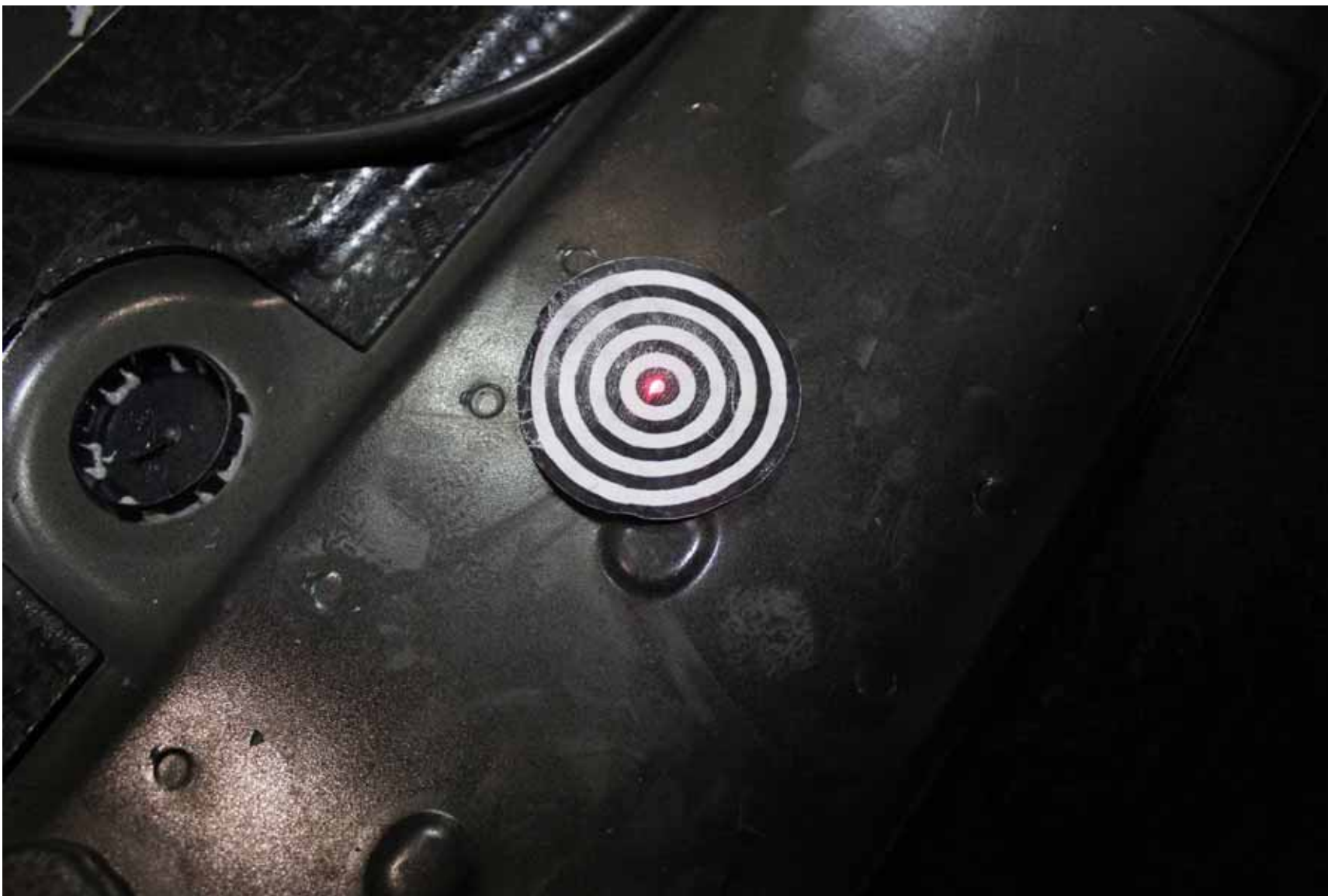




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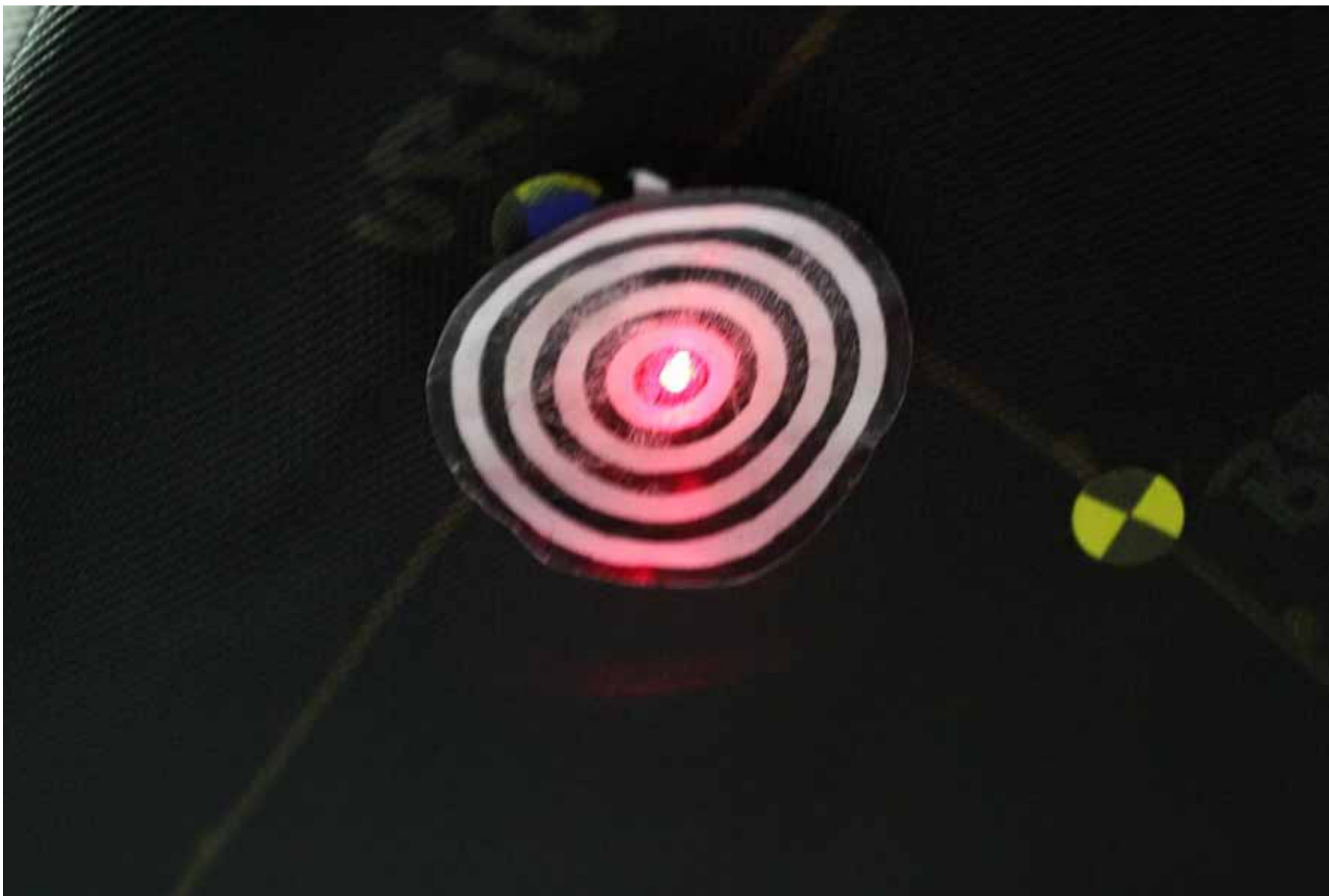
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Pre-Test Photograph No. 24 of Test R20204



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Pre-Test Photograph No. 25 of Test R20204





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Pre-Test Photograph No. 29 of Test R20204





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Pre-Test Photograph No. 30 of Test R20204



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NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825

FMVSS 216a Driver Side Roof Crush

Contract #DTNH2216D00028 / NHTSA #C20204100

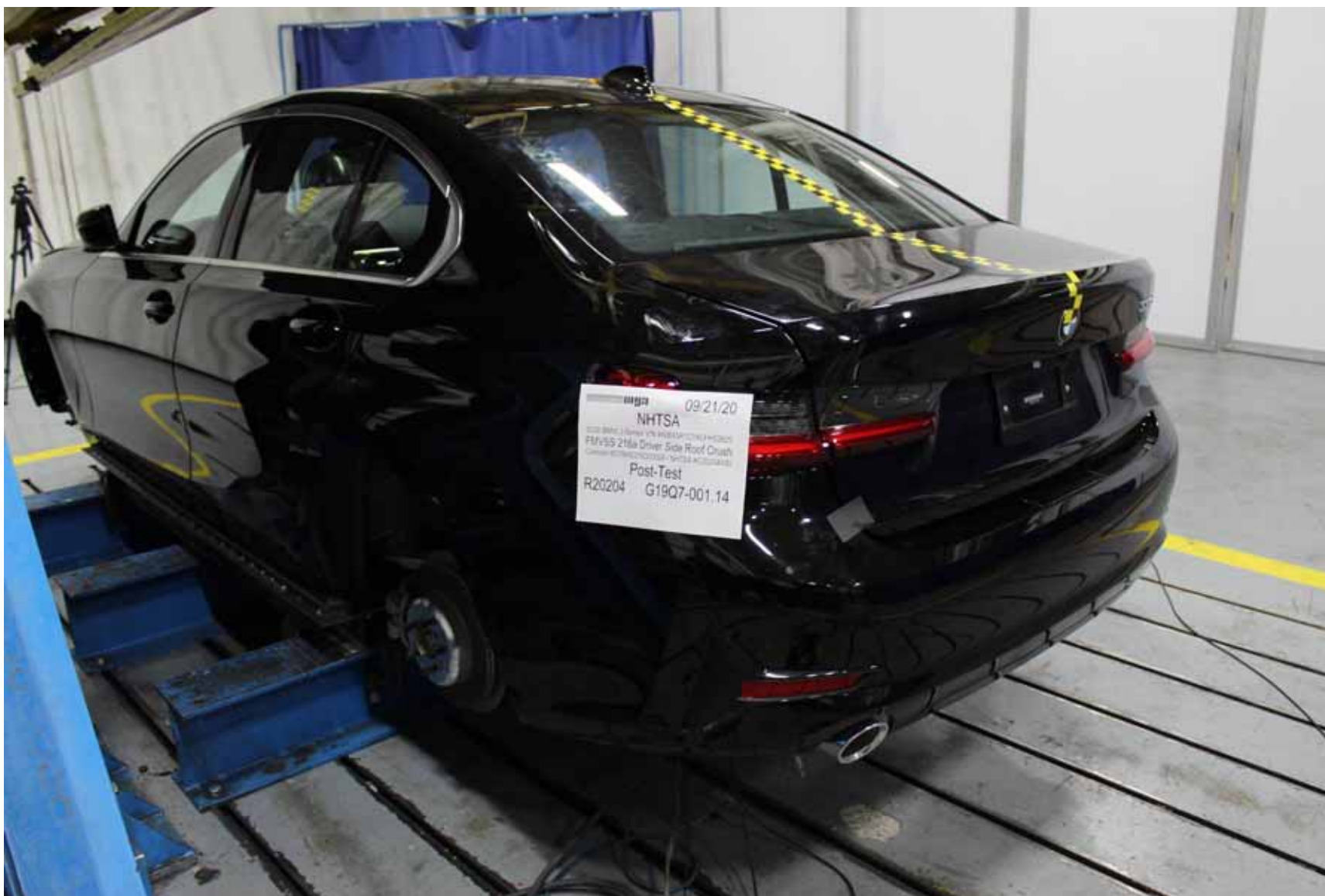
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R20204

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Post-Test Photograph No. 2 of Test R20204





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Post-Test Photograph No. 3 of Test R20204



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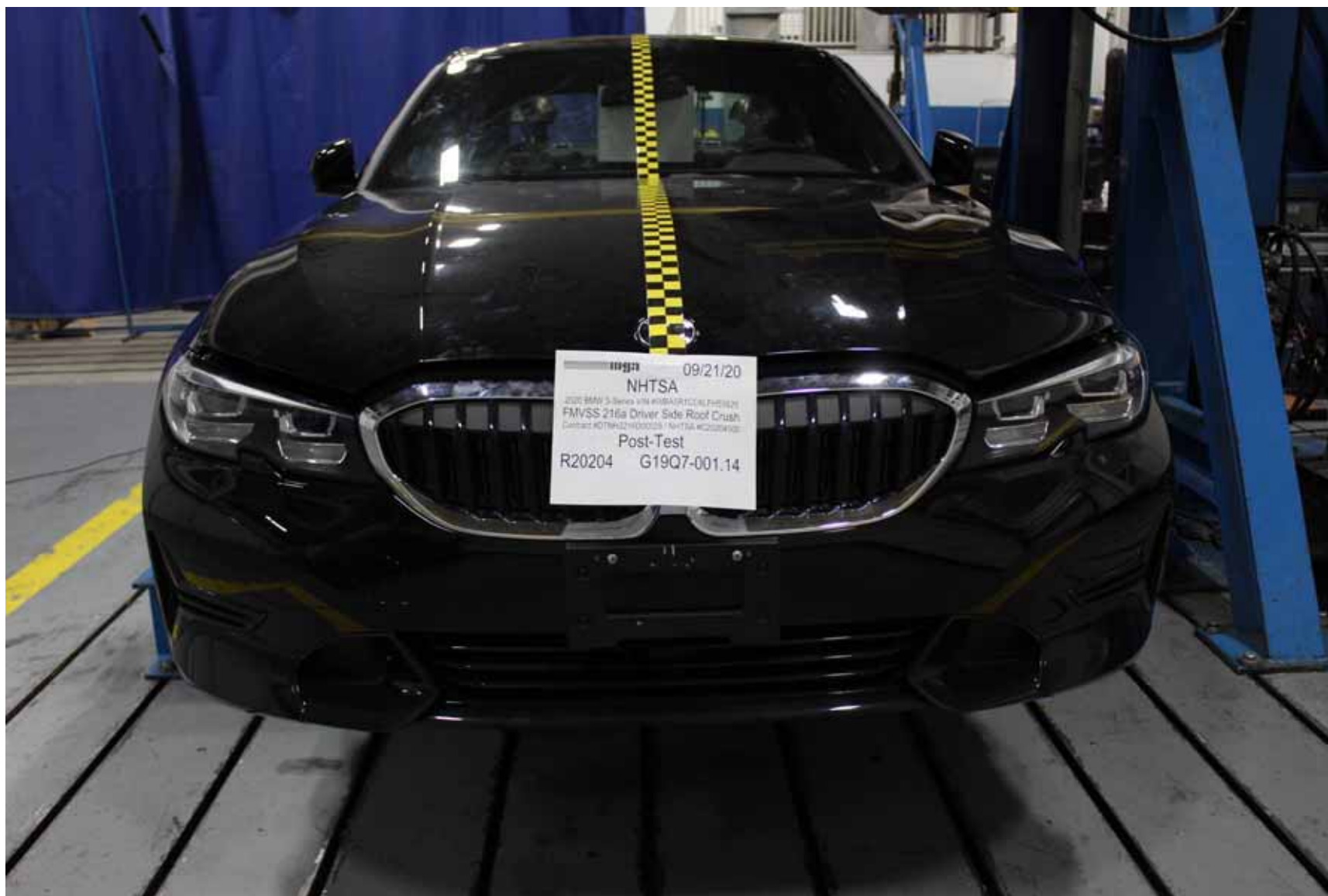
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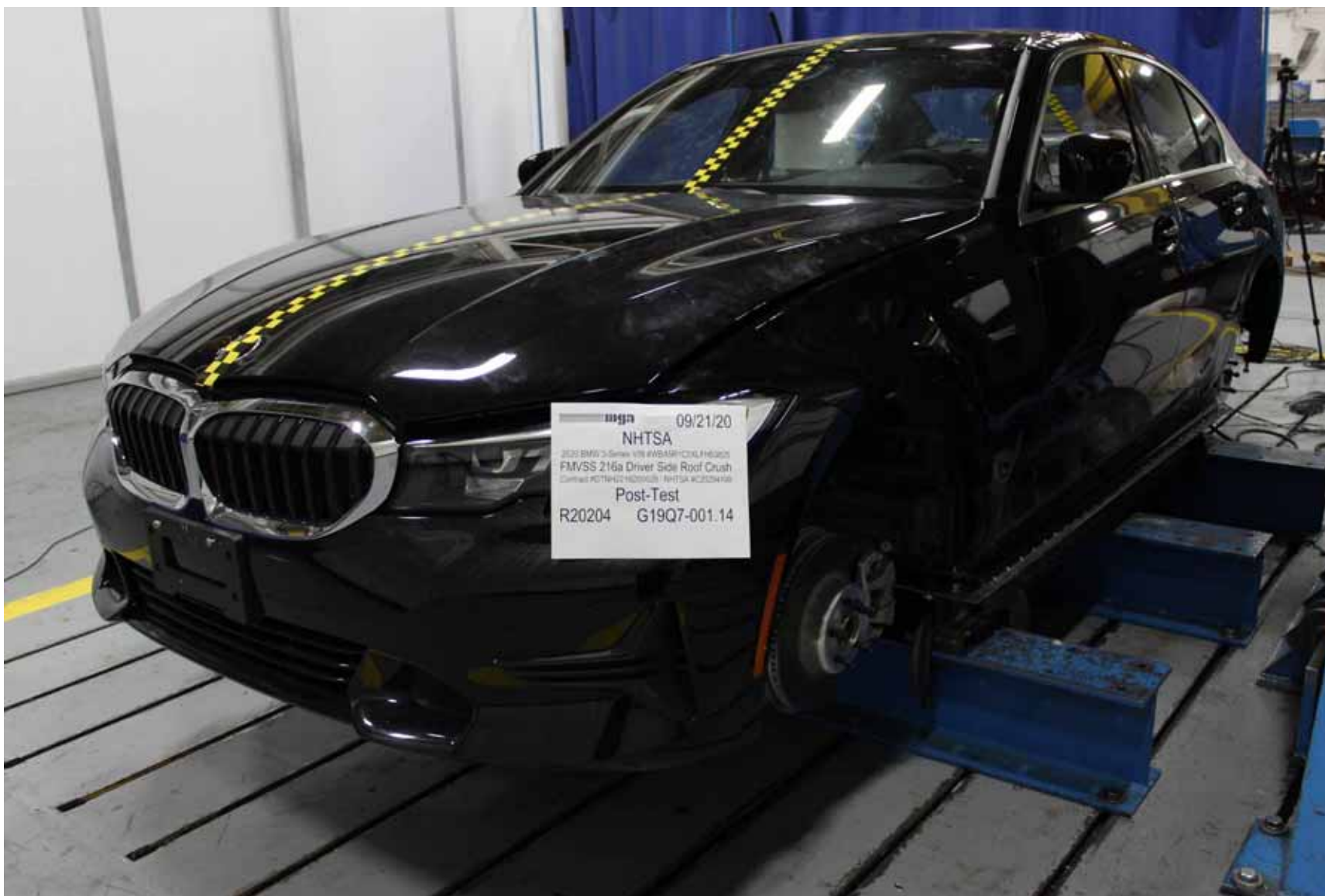
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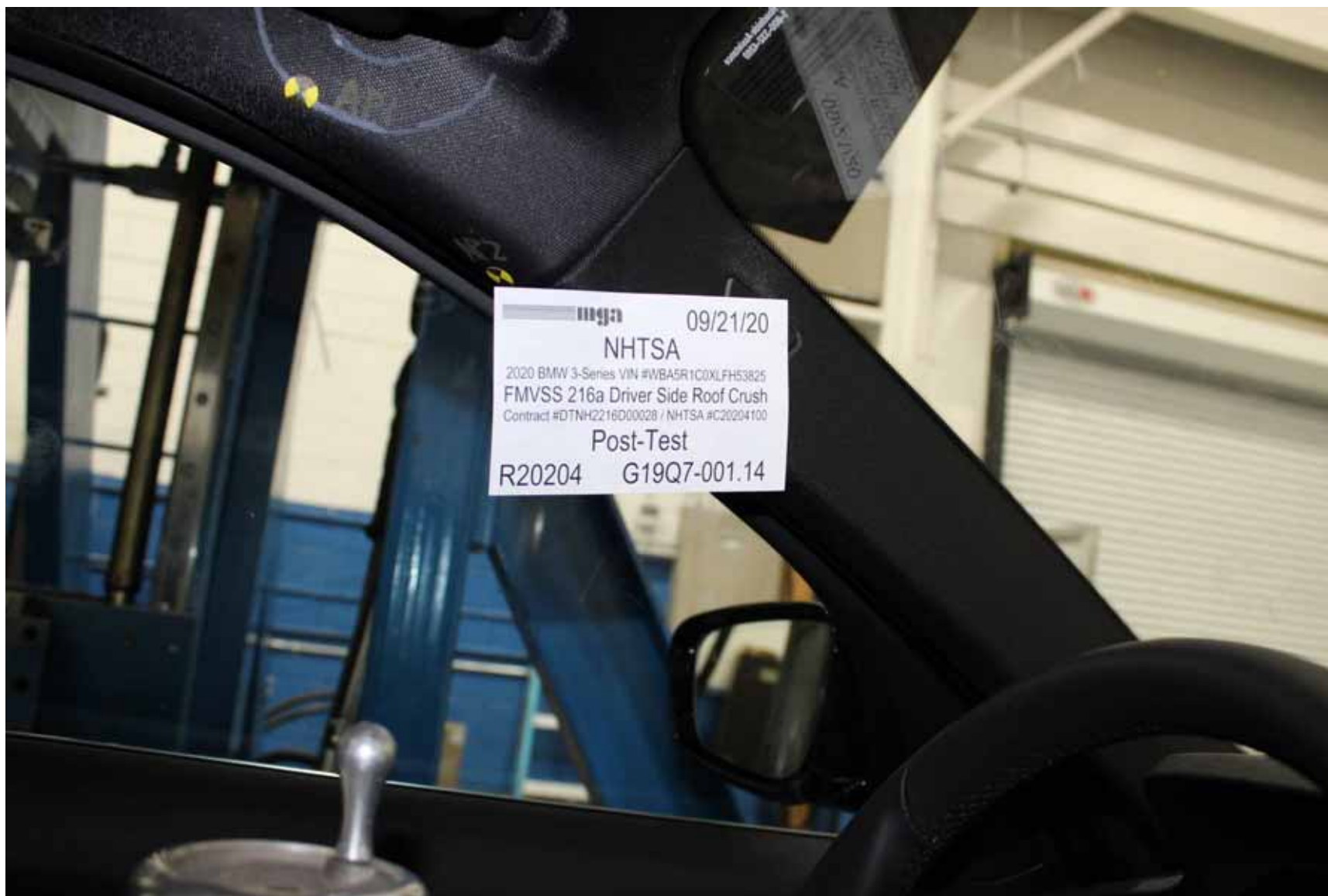
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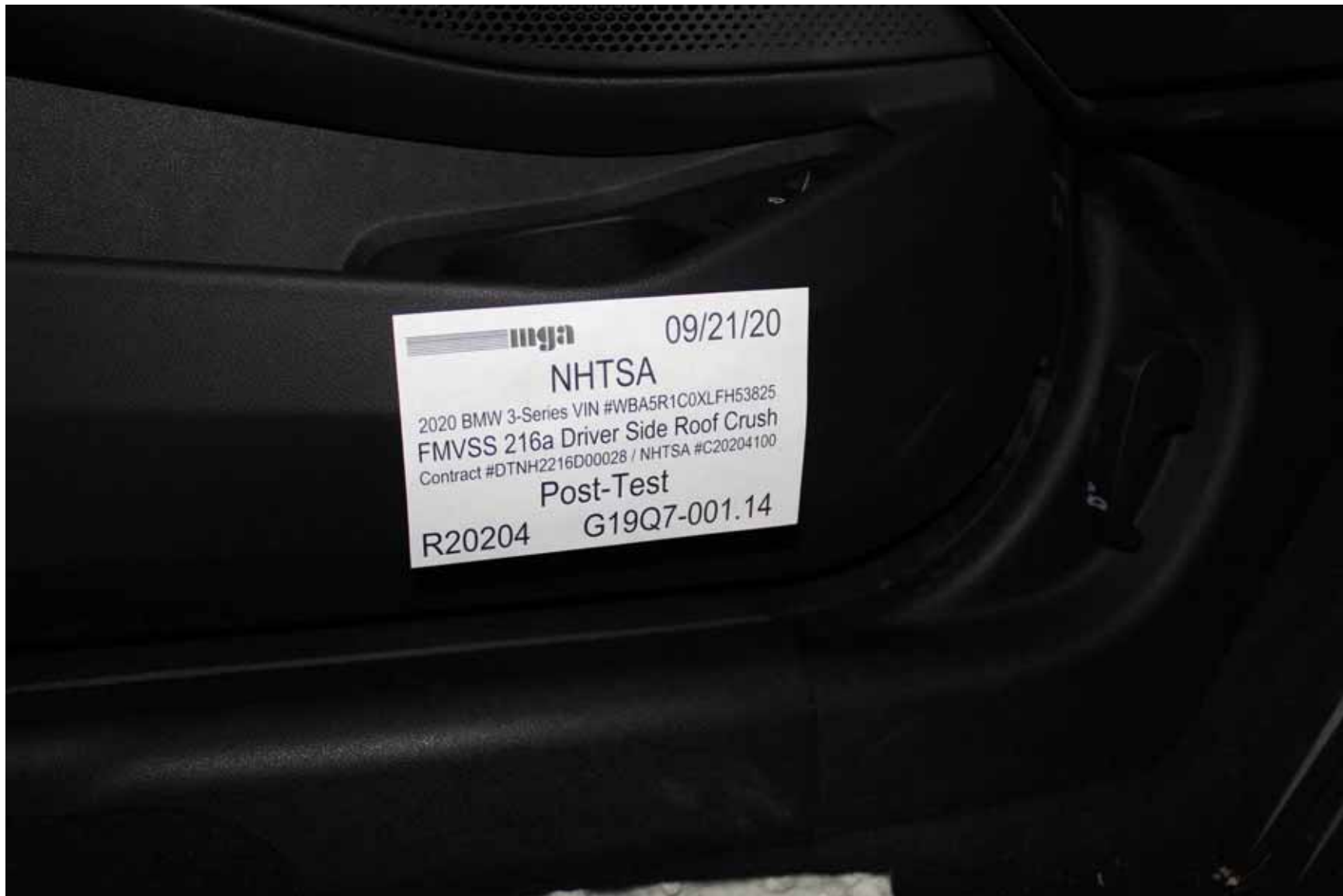
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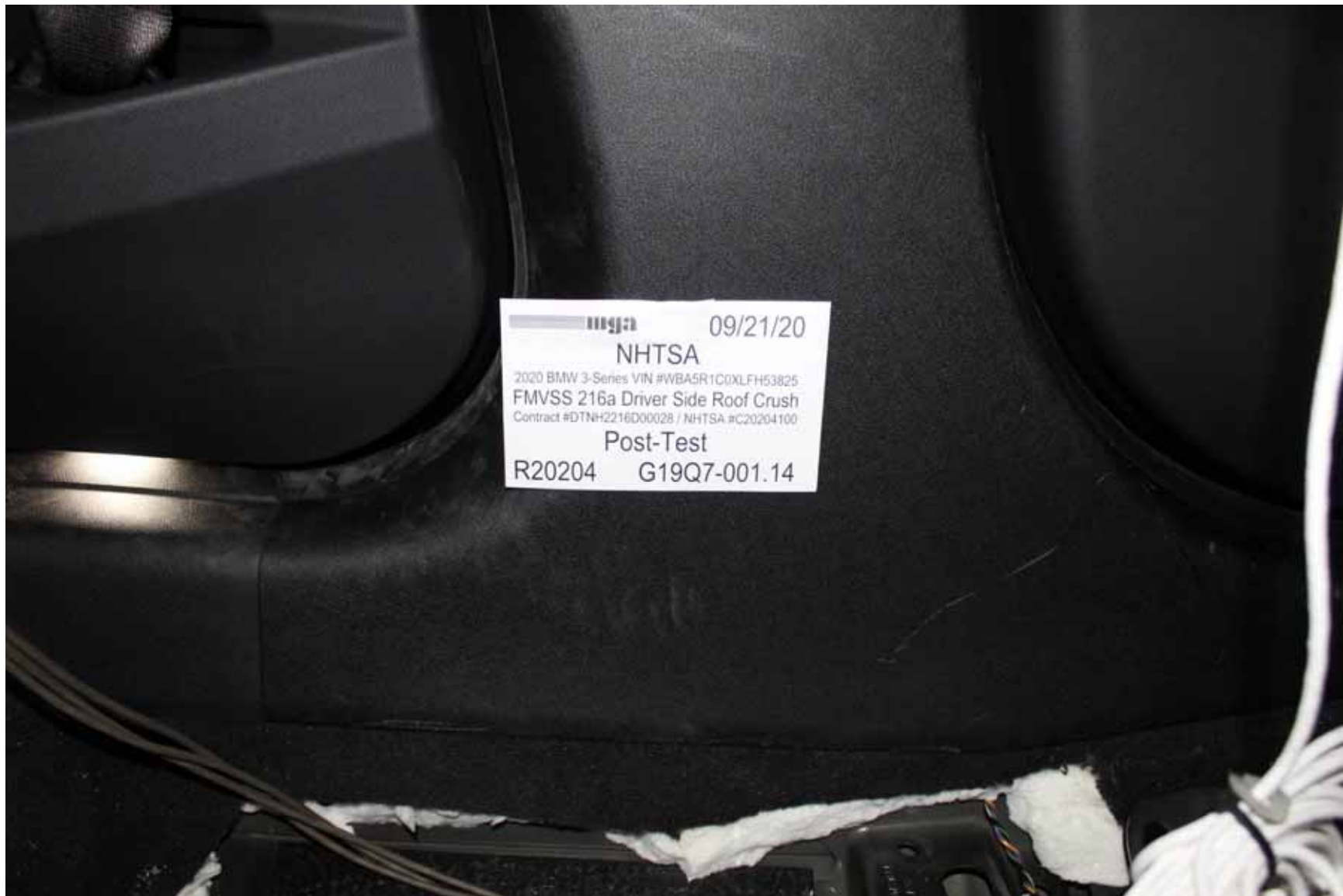
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Post-Test Photograph No. 17 of Test R20204



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Post-Test Photograph No. 18 of Test R20204



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FMVSS No. 216a

Post-Test Photograph No. 19 of Test R20204



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Post-Test Photograph No. 20 of Test R20204





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Post-Test Photograph No. 21 of Test R20204





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NHTSA No. C20204100  
FMVSS No. 216a

Post-Test Photograph No. 22 of Test R20204



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NHTSA No. C20204100  
FMVSS No. 216a

Post-Test Photograph No. 23 of Test R20204



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Post-Test Photograph No. 24 of Test R20204





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NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825  
FMVSS 216a Passenger Side Roof Crush  
Contract #DTNH2216D00028 / NHTSA #C20204100

Pre-Test

R20205

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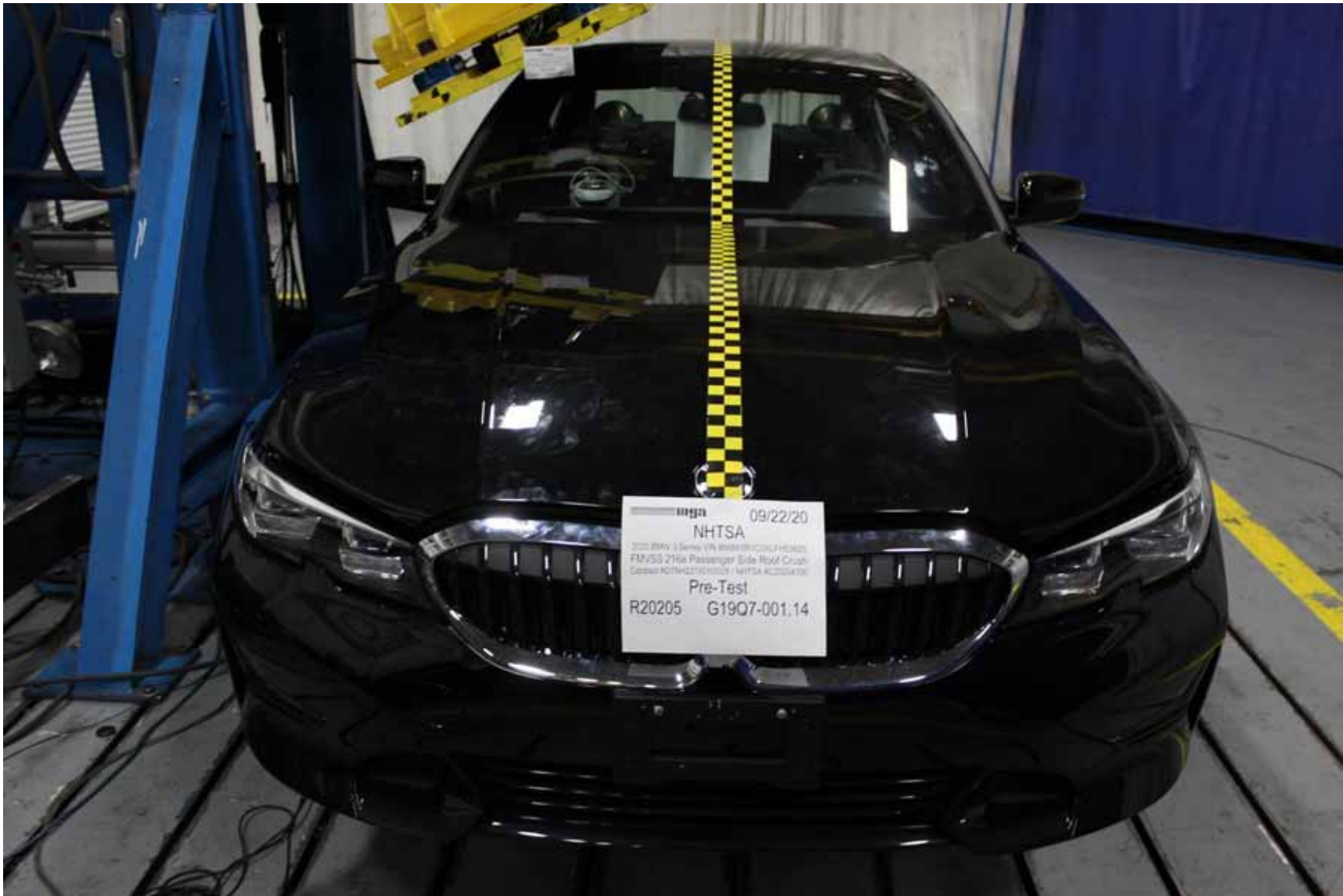
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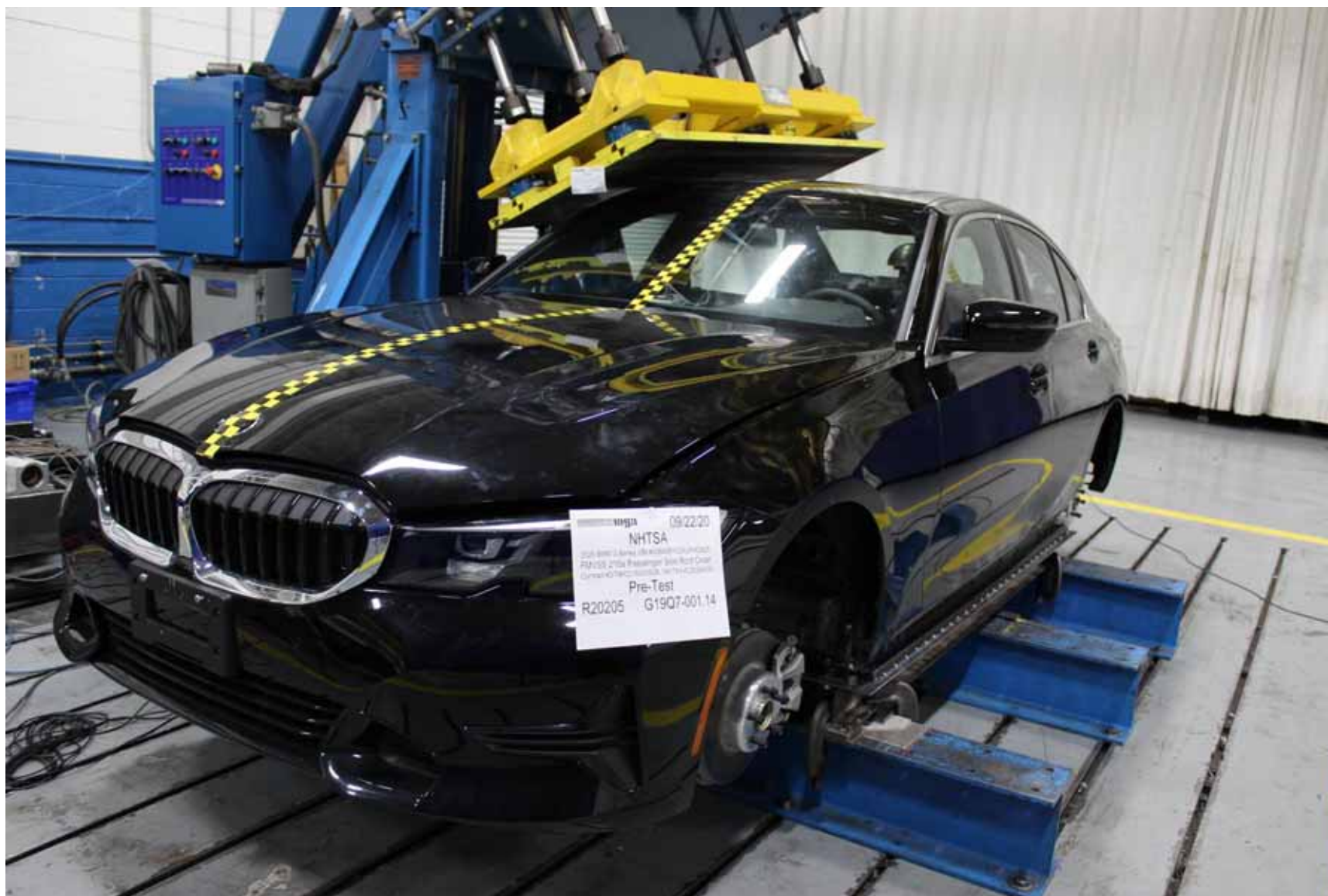
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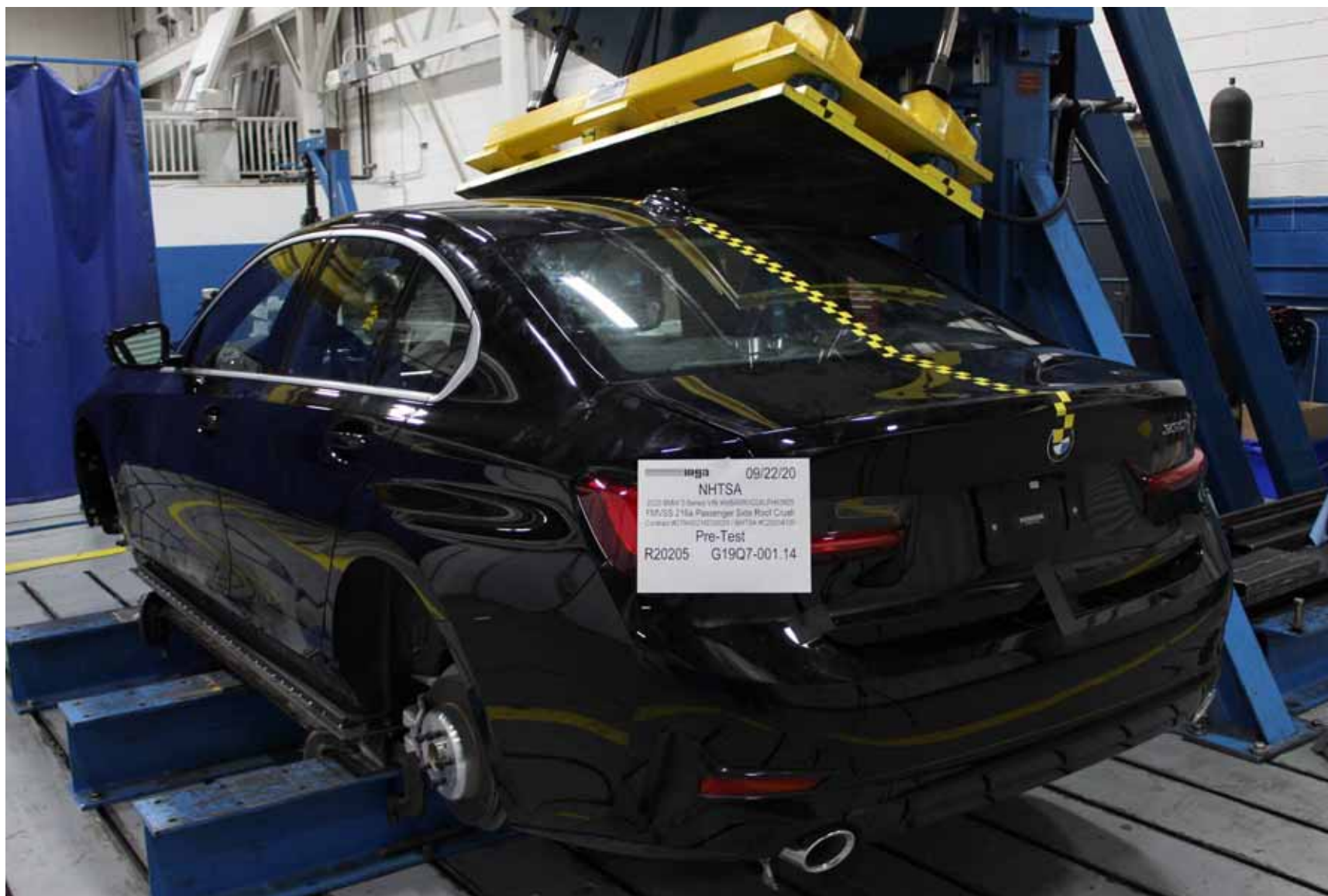
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Pre-Test Photograph No. 6 of Test R20205





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Pre-Test Photograph No. 7 of Test R20205





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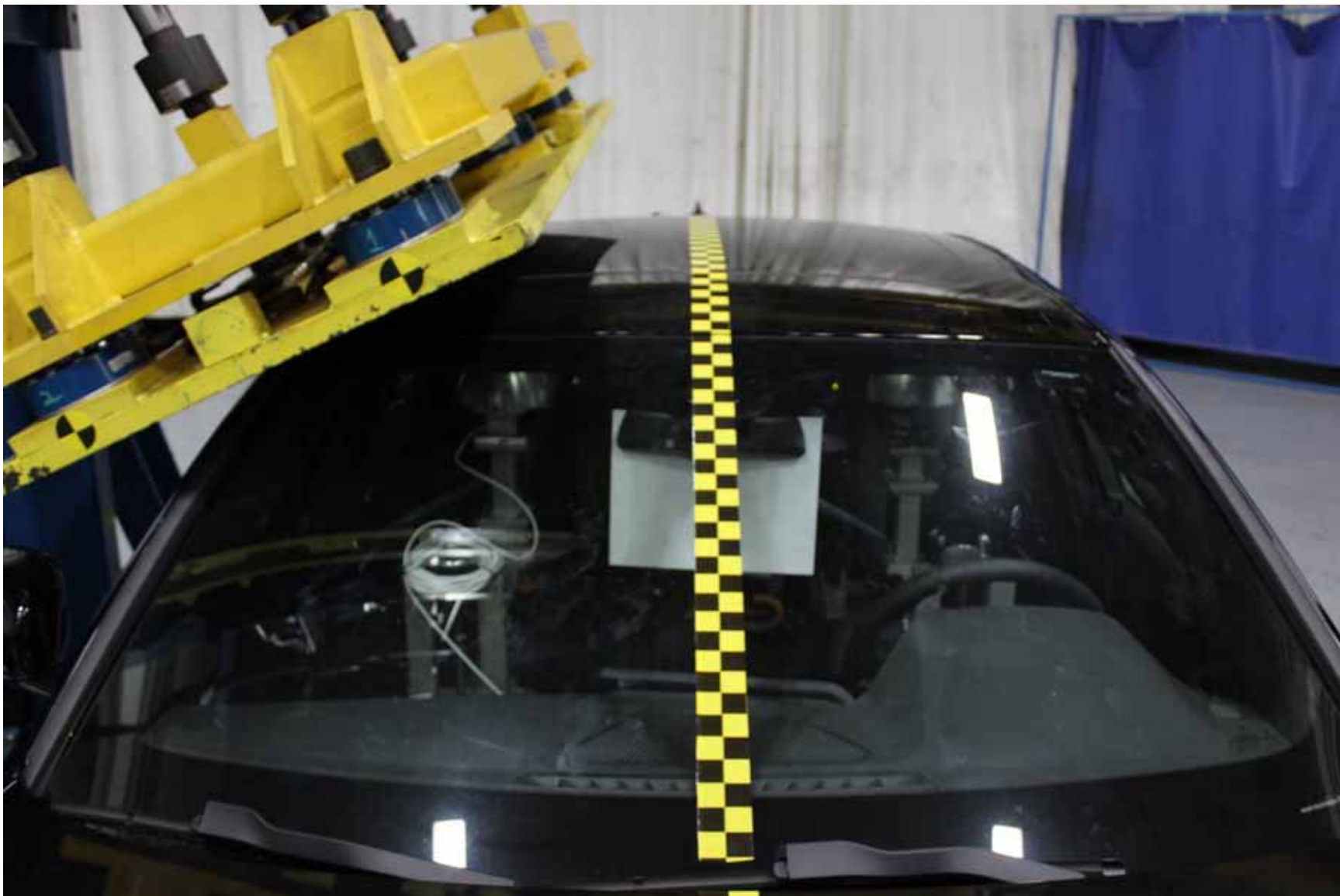
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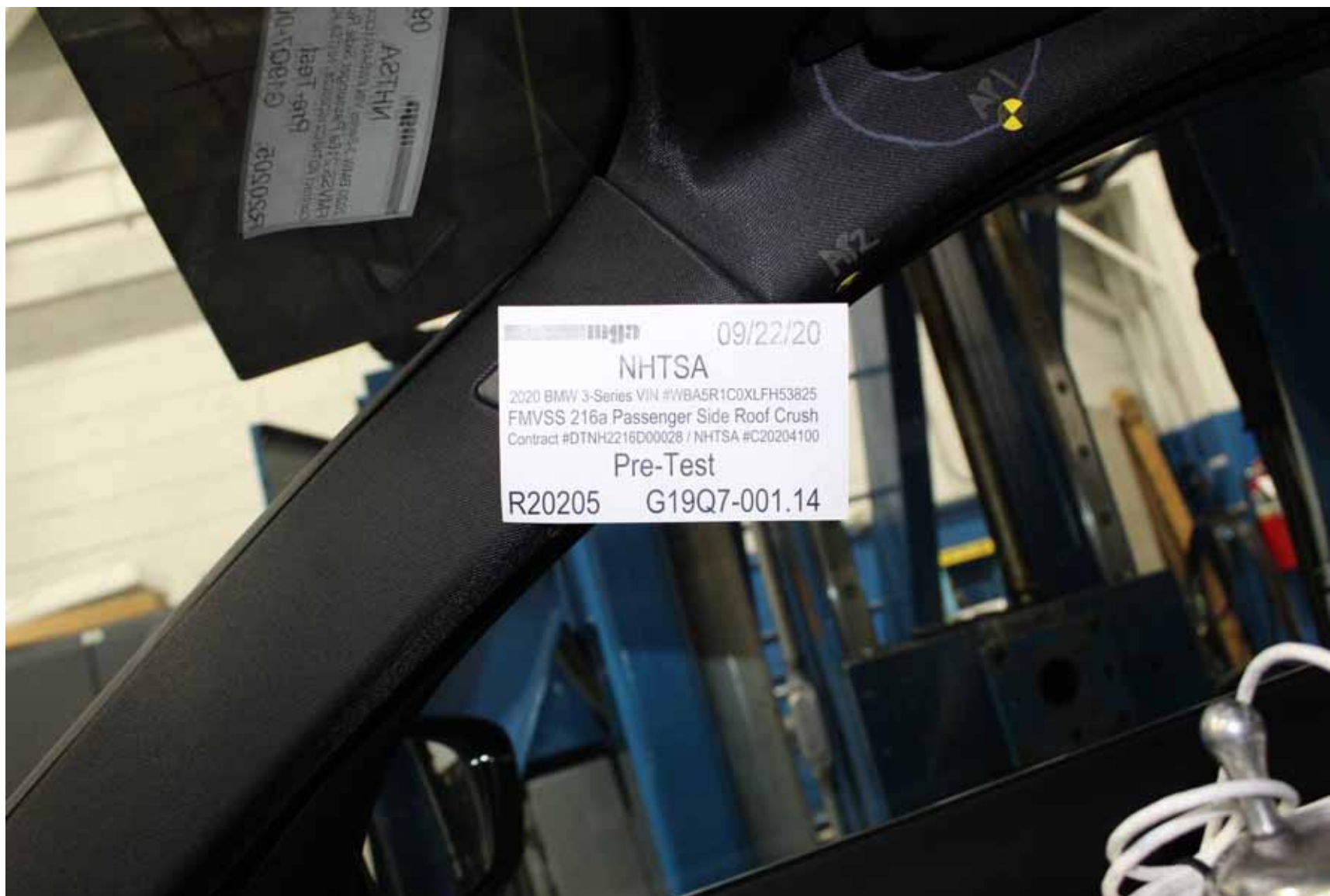
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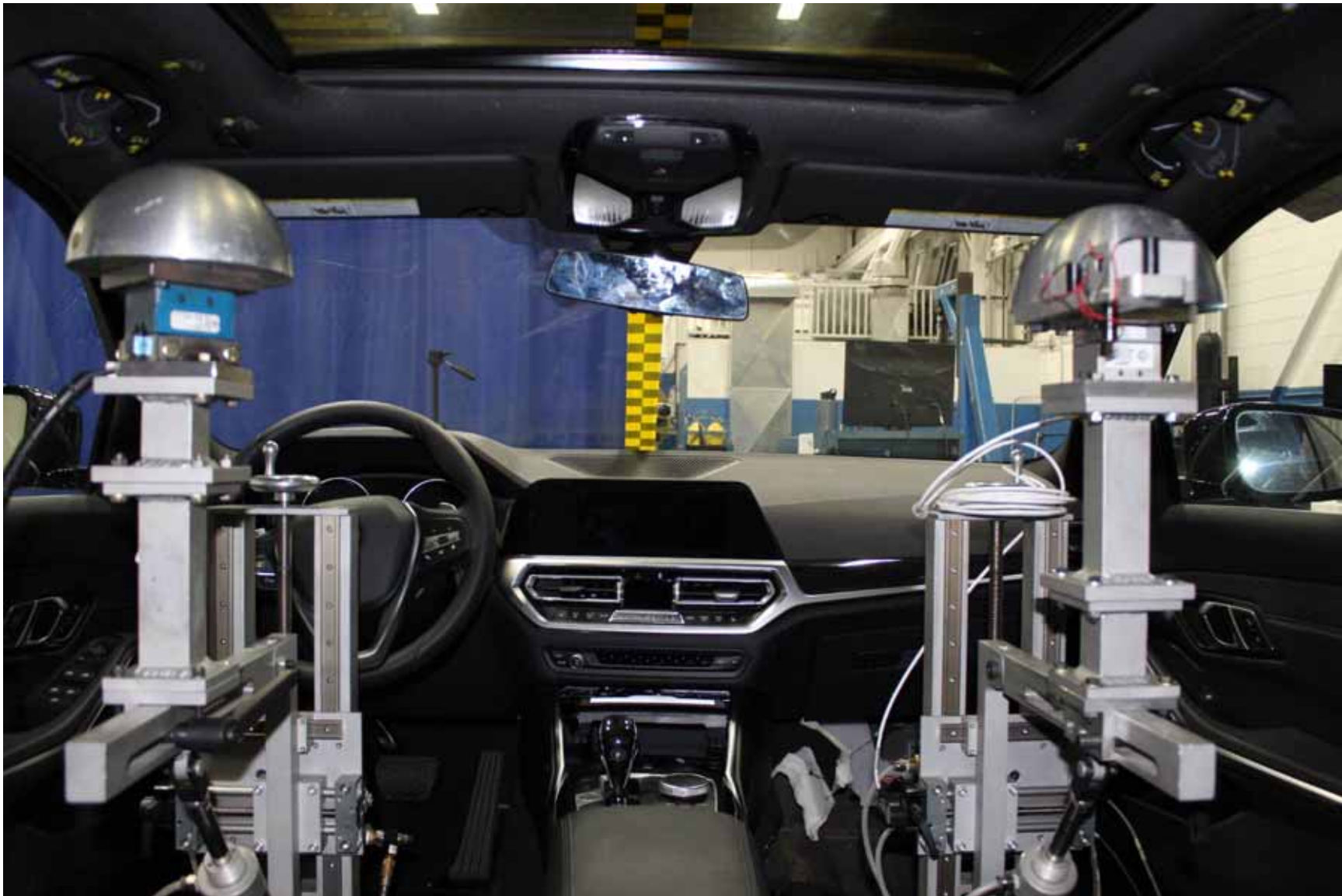
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Pre-Test Photograph No. 19 of Test R20205



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Pre-Test Photograph No. 20 of Test R20205





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Pre-Test Photograph No. 21 of Test R20205



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FMVSS No. 216a

Pre-Test Photograph No. 22 of Test R20205





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Pre-Test Photograph No. 23 of Test R20205



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Pre-Test Photograph No. 26 of Test R20205



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FMVSS No. 216a

Pre-Test Photograph No. 27 of Test R20205





09/22/20

NHTSA

2020 BMW 3-Series VIN #WBA5R1C0XLFH53825  
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Contract #DTNH2216D00028 / NHTSA #C20204100

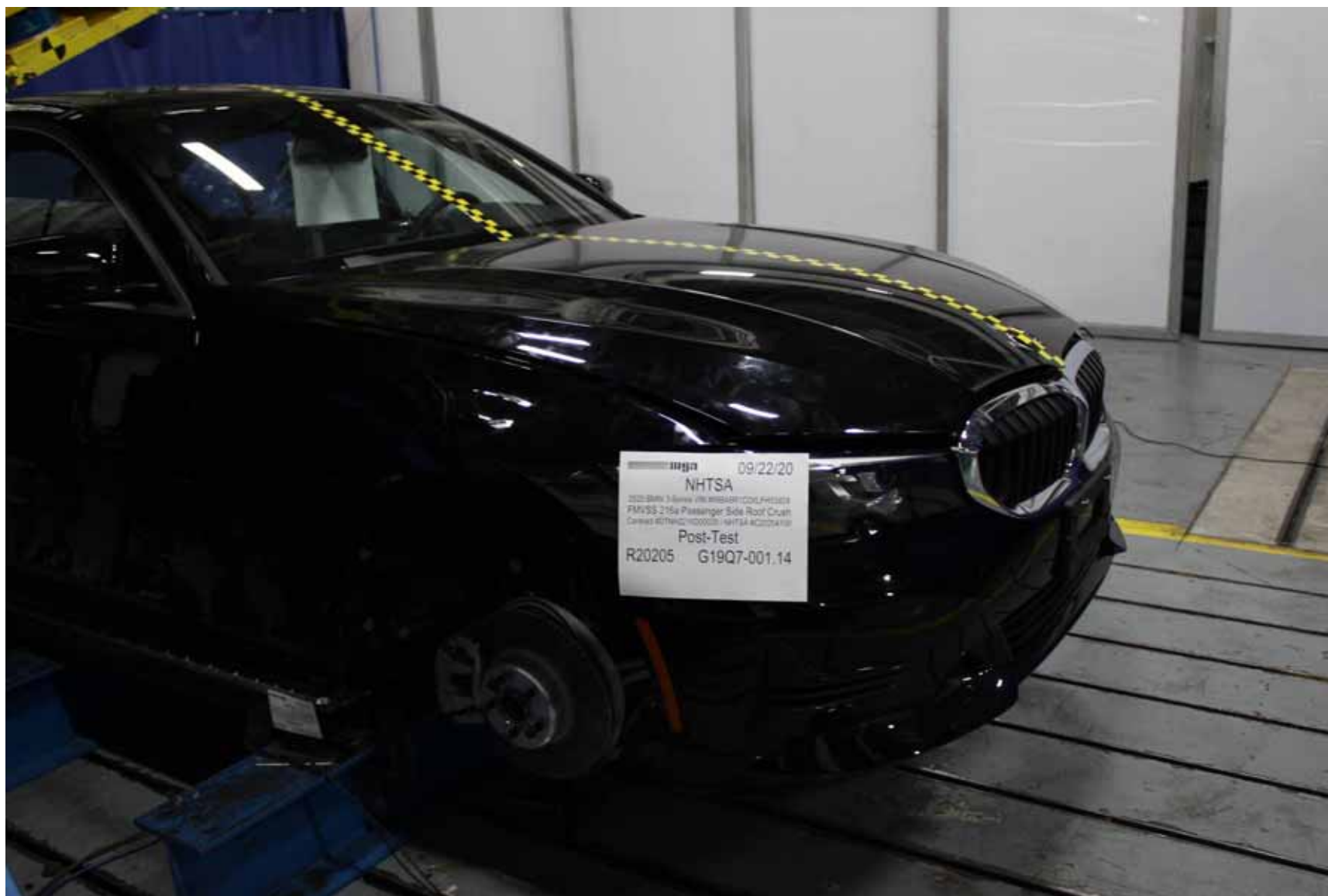
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R20205

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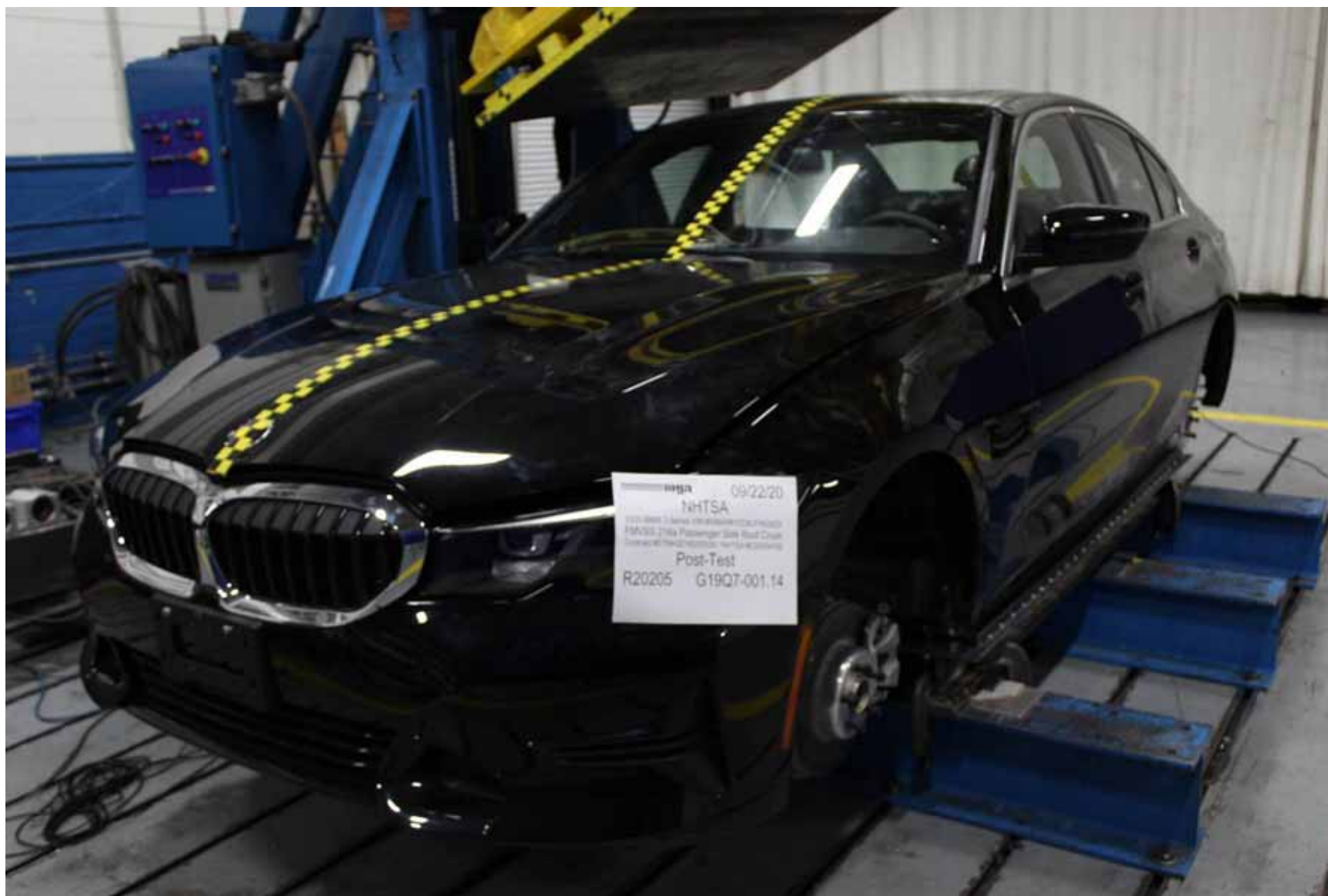
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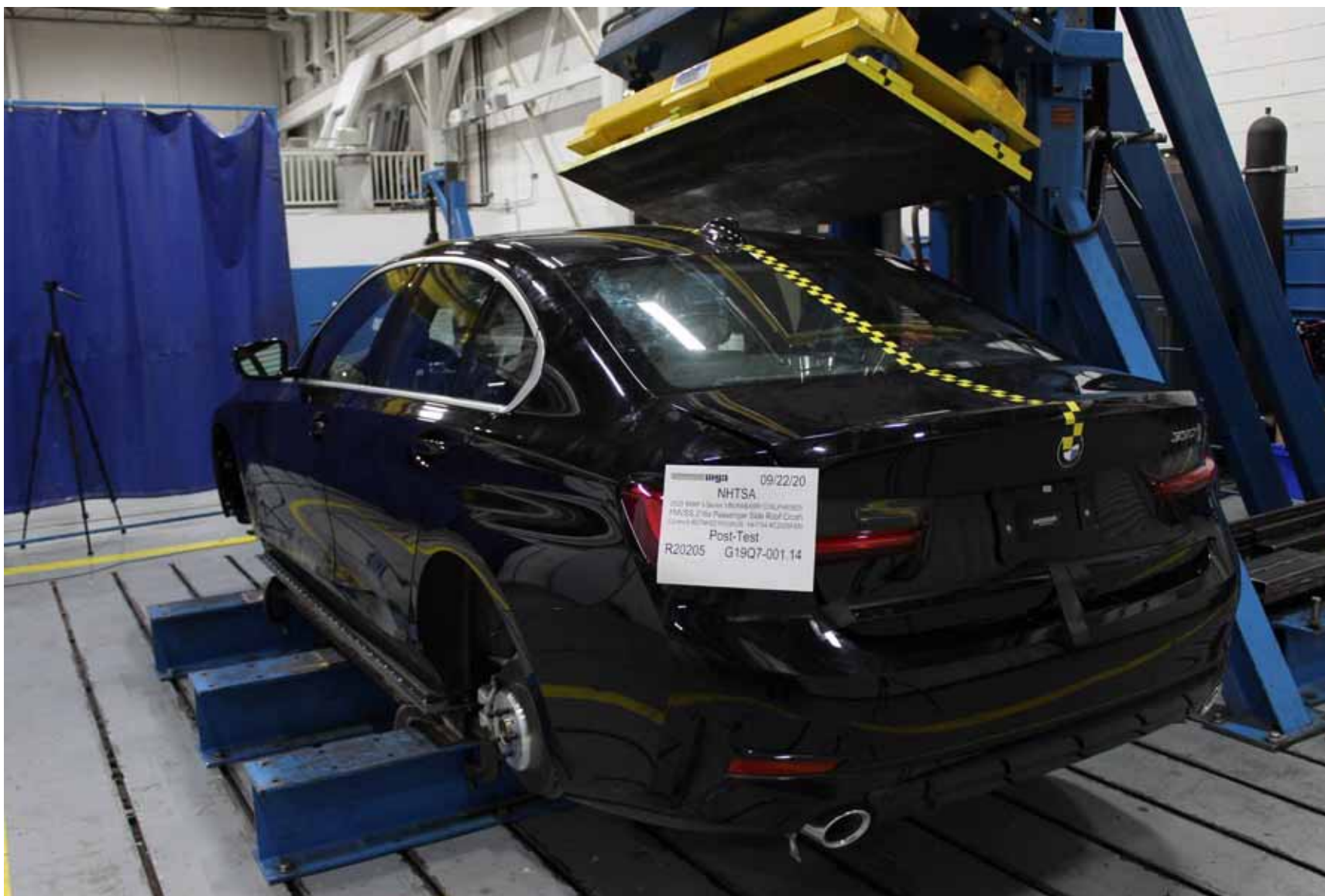
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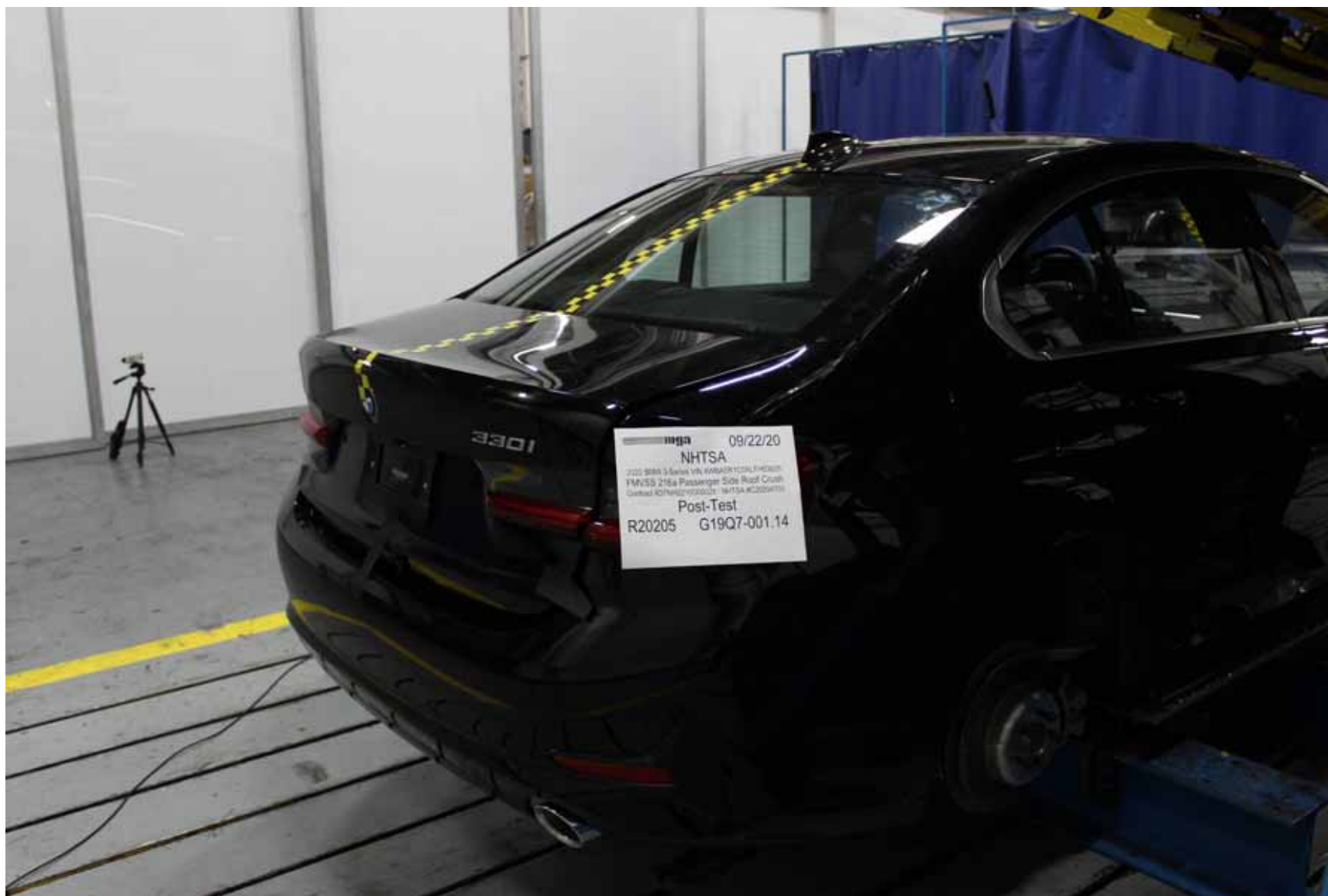
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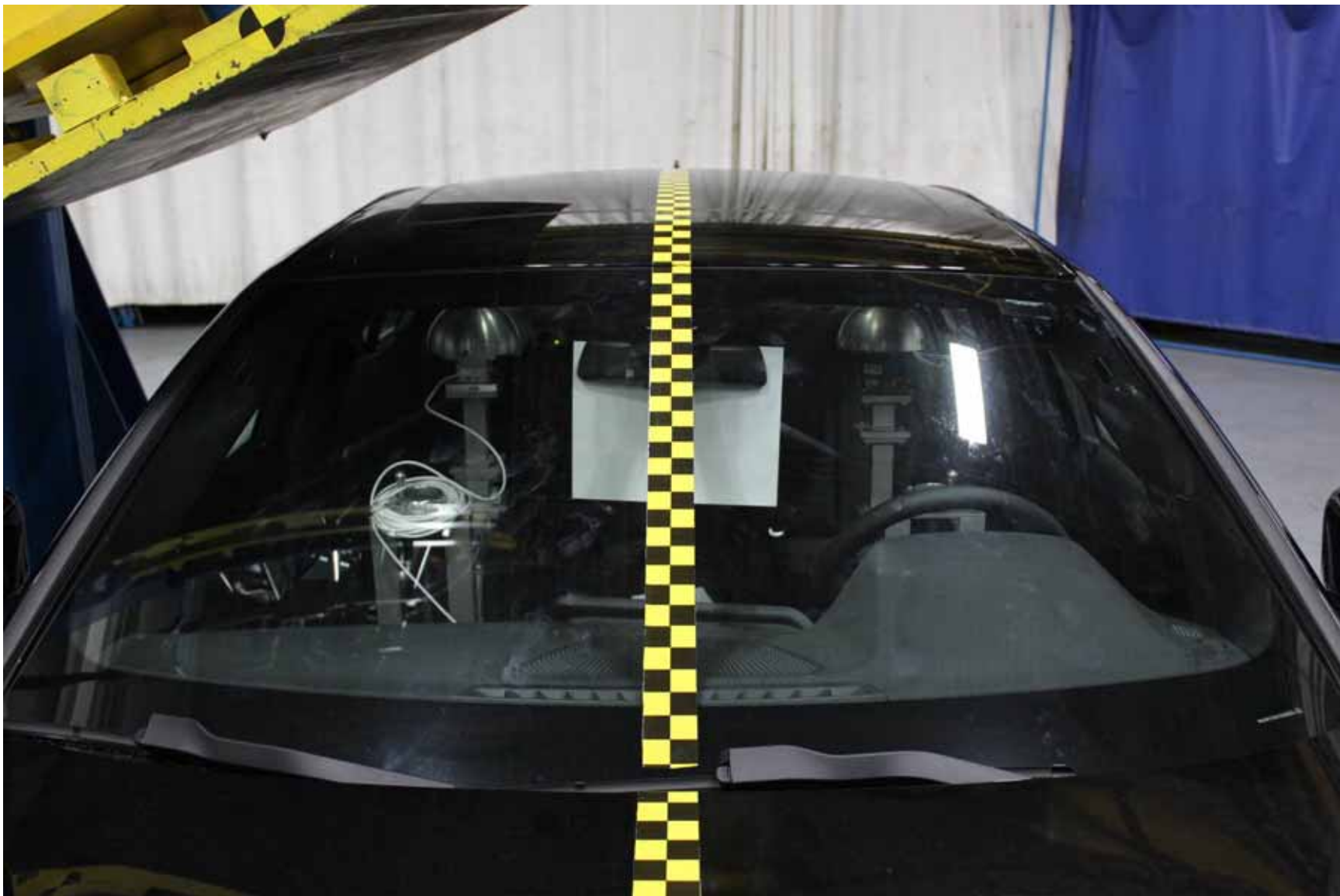
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Post-Test Photograph No. 9 of Test R20205



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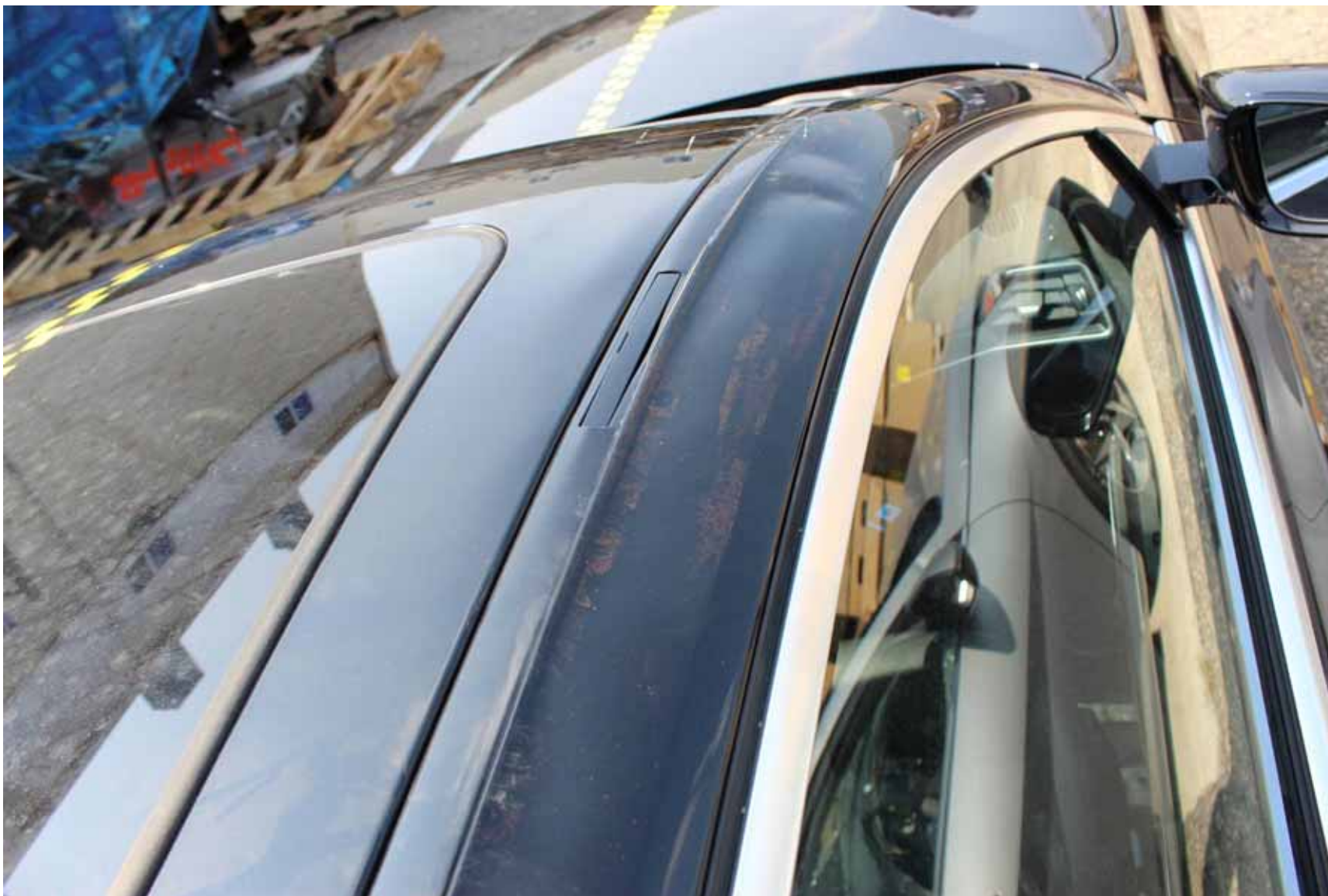
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Post-Test Photograph No. 11 of Test R20205





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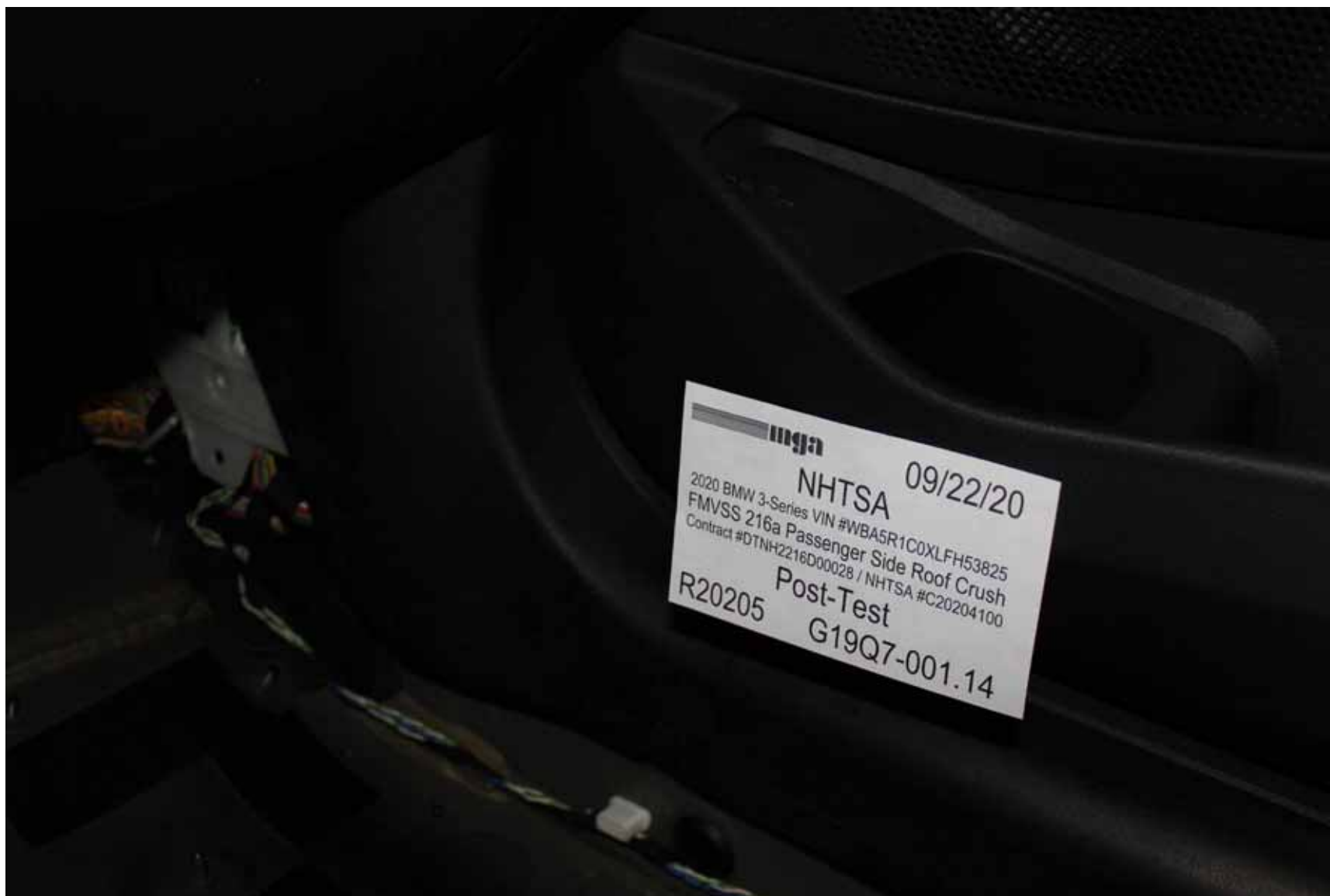
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FMVSS No. 216a

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FMVSS No. 216a

Post-Test Photograph No. 15 of Test R20205



2020 BMW 3-Series  
NHTSA No. C20204100  
FMVSS No. 216a

Post-Test Photograph No. 16 of Test R20205





2020 BMW 3-Series  
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FMVSS No. 216a

Post-Test Photograph No. 17 of Test R20205



2020 BMW 3-Series  
NHTSA No. C20204100  
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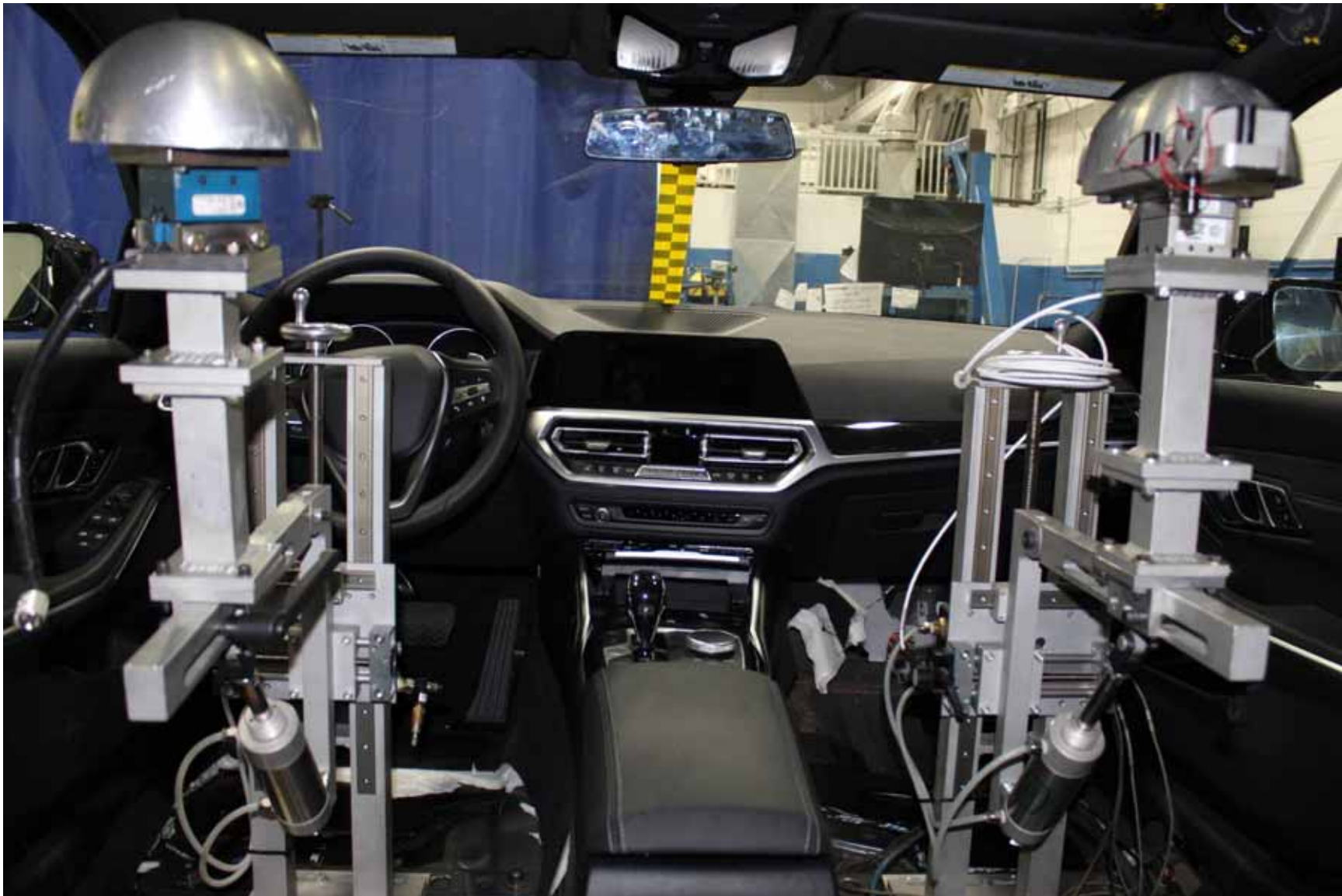
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Post-Test Photograph No. 20 of Test R20205





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FMVSS No. 216a

Post-Test Photograph No. 21 of Test R20205



2020 BMW 3-Series  
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FMVSS No. 216a

Post-Test Photograph No. 22 of Test R20205

6.0 Test Data Plots

